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TELEOST SPECIES RECORDED IN TUNIS SOUTHERN LAGOON AFTER ITS ENVIRONMENTAL RESTORATION (NORTHERN TUNISIA, CENTRAL MEDITERRANEAN)

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ABSTRACT

During the investigations conducted after an environmental restoration of Tunis Southern Lagoon, close to the Gulf of Tunis in northern Tunisia, 62 teleost species were collected, 48 of which were recorded in the area for the first time. Of the 62 teleosts, 13 were sedentary, 26 marine and 23 regular migratory species. Their occurrence in the area is discussed in the present article.

Key words: Osteichthyes, teleosts, environmental restoration, Tunis Southern Lagoon, Tunisia, Central Mediterranean

SPECIE DI TELEOSTEI SEGNALATE NELLA LAGUNA MERIDIONALE DI TUNISI DOPO UN RESTAURO AMBIENTALE (TUNISIA SETTENTRIONALE, MEDITERRANEO CENTRALE)

SINTESI

Le ricerche condotte nella laguna meridionale di Tunisi, prossima al Golfo di Tunisi, nella Tunisia settentrionale, in seguito ad un restauro ambientale, hanno portato alla raccolta di 62 specie di teleostei, 48 delle quali sono state segnalate per la prima volta per quest'area. Delle 62 specie raccolte, 13 sono sedentarie, 26 marine e 23 specie che migrano regolarmente. L'articolo discute il loro ritrovamento in quest'area.

Parole chiave: Osteitti, Teleostei, restauro ambientale, laguna meridionale di Tunisi, Tunisia, Mediterraneo centrale

INTRODUCTION

The Lagoon of Tunis, adjoining the city of Tunis, is located in the southwestern Gulf of Tunis (Figs. 1, 2). It is divided in two areas by a navigation channel, *i.e.* into Tunis Northern Lagoon and Tunis Southern Lagoon. In the past, both areas were severely anthropically polluted (Zaouali, 1983; Ben Souissi, 2002). They required a thorough environmental restoration, which has been recently indeed achieved (Vandenbroek & Ben Charrada, 2001; Ben Souissi, 2002; Ben Souissi *et al.*, 2003). Investigations were carried out in Tunis Southern Lagoon to assess the restoration influence on the inside environment. They showed a significant improvement of ecological parameters and allowed to record invertebrate species previously unknown in the lagoon, the nearby Gulf of Tunis, and beyond, along the Tunisian coast. With special regard to ichthyofauna, Méjri *et al.* (2004; *in press*) reported on the occurrence of seven elasmobranch species, while Ben Souissi *et al.* (2004) confirmed for the first time the John Dory, *Zeus faber* 1758, in a perimediterranean lagoon. Further investigations provide additional records of teleost species in Tunis Southern Lagoon, allowing us to evaluate whether there is a significant improvement in environmental parameters after the restoration of the area and the role of marine flux in teleost diversity. So, a historical comparison of Tunis Southern Lagoon ichthyofauna before and after the environmental restoration is made. The teleost species recently found in the area are listed and their occurrence discussed. Moreover, a comparison between ichthyofauna of Tunis Southern Lagoon and those of other perimediterranean lagoons is carried out.

MATERIAL AND METHODS

At present, Tunis Southern Lagoon covers 720 ha, with a regular depth at about 2 m throughout the lagoon, except in restricted areas where it reaches 4 m at the most (see figure 2).

It appears as an elongated ellipse directed SW-NE, 36°46′47″and 36°48′00″ N, and 10°12′22″ and 10°16′ 41″ E. The navigation channel, 10 km long and max.12 m deep, constitutes *pro parte* the northern border of Tunis Southern Lagoon.

Before the environmental restoration, the mean monthly salinity ranged between 30.9 and 48.9 psu; after the restoration, it ranged between 37 and 38.3 psu and the monthly average was 37.8 psu (Ben Souissi *et al.*, 2003). Moreover, both monthly and annual temperature values did not show significant differences before and after the restoration (Ben Souissi *et al.*, 2003). Ben Souissi *et al.* (1999, 2000, 2001, 2003) showed that both nitrates and phosphorus rates reached high levels in both water and sediments before the environmental restoration. By contrast, Ben Souissi et *al.* (2003) observed a significant reduction of both nitrates and phosphorus rates after the environmental restoration.

Our ichthyofaunal investigations were regularly conducted between 2001 and 2004. Juvenile as well as adult fishes were directly collected at fishing sites throughout the area, three times per week, at least, soon after they were landed. They were caught mainly by gillnets and tramails, occasionally by cast-nests, landing-nets, anglers and diving. Fresh and sometimes alive specimens were examined. The species recorded in Tunis Southern Lagoon before and after the environmental restoration were divided into three categories following Quignard & Zaouali (1980).

The first category includes sedentary species that are generally of small size and are abundantly as well as regularly caught all year round in the lagoons. The second category comprises species entering the lagoons occasionally or accidentally straying from migratory movements. They develop and reproduce only in offshore areas. The third category concerns species of which fry and juveniles (0+) enter the lagoons to find sufficient resources and to develop. These species constitute a mid-term between the two above categories; they are 'mixed species' or rather regular migratory species.

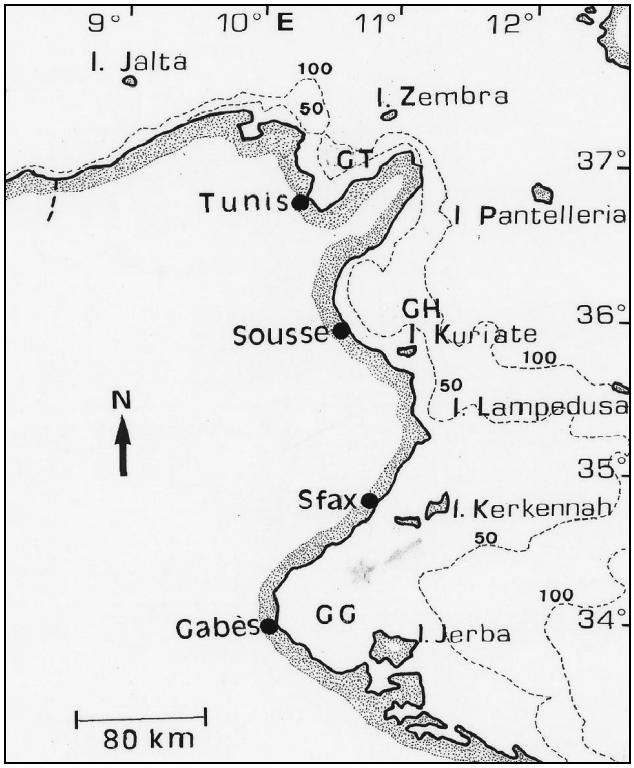

Fig. 1: Map of Tunisia, with the Gulf of Tunis (GT), the Gulf of Hammamet (GH), and the Gulf of Gabès (GG).
Sl. 1: Zemljevid Tunizije s Tuniškim (GT), Hammametskim (GH) in Gabeškim zalivom (GG).

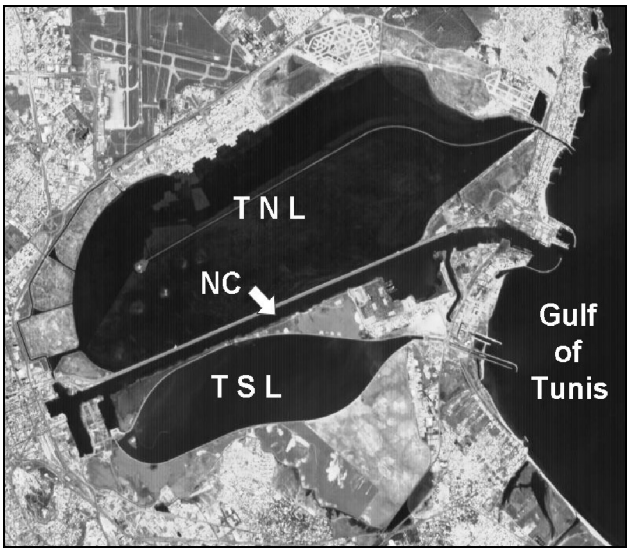

Fig. 2: Map of Tunis Lagoon, divided by navigation channel (NC) in two areas: Tunis Northern Lagoon (TNL) and Tunis Southern Lagoon (TSL) after the environmental restoration.
Sl. 2: Zemljevid Tuniškega zaliva – ki ga navigacijski kanal (NC) deli na dve območji: Tuniško severno laguno (TNL) in Tuniško južno laguno (TSL) – po njegovem okoljskem restavriranju.

With special regard to their abundance in Tunis Southern Lagoon, four categories of species were also considered:

- species abundantly caught throughout the year, commonly caught throughout the year, or during one or some periods of the year;
- species frequently caught throughout the year or in one or some periods of the year;
- species rarely caught throughout the year or in some period of the year;
- species occasionally caught.

Moreover, in order to characterize teleost biodiversity in Tunis Southern Lagoon, we followed Bradaï *et al.* (2004) who consider three categories of species based on their geographic distribution, such as: Atlanto-Mediterranean (AM), cosmopolitan (C), endemic (E) and their affinities comprising three categories, such as species belonging to cold water fauna (CWF), thermophilous species (TS) and unclassified (U).

RESULTS

Of the 62 species recorded to date, 13 were sedentary (21%), 26 marine (42%) and 23 regular migratory species (37%). Of the 48 species recorded for the first time in Tunis Southern Lagoon, eleven were sedentary, 15 marine and 22 regular migratory species.

Most of the observed specimens were juveniles. However, some species such as *Atherina boyeri, Belone belone* and *Zosterisessor ophiocephalus* comprised mature specimens expelling spermatozoa or oocytes when caught. Of the species recorded in Tunis Southern Lagoon, six are commonly caught all the year round in the area, *i.e. Mugil cephalus, Anguilla anguilla, Liza aurata, Liza ramada, Diplodus annularis* and *Dicentrarchus labrax*, which are considered to be of economical interest.

Of the 62 teleost species recorded, 4 were abundantly, 33 commonly, 22 rarely and 3 occasionally caught in the area (Tab. 1). This suggests that many of the species probably began to establish themselves in Tunis Southern Lagoon. Moreover, of the 13 sedentary species, 3 were endemic, and 10 Atlanto-Mediterranean, with regard to their marine affinities, 7 species were unclassified, and 6 thermophilous. Of the 26 marine species, 1 species was endemic, 24 Atlanto-Mediterranean and 1 cosmopolitan, 17 belonged to thermophilous fauna, a single one to cold water fauna and 8 were unclassified. Of the 23 regular migratory species, a single species was endemic, the remaining 22 Atlanto-Mediterranean; 17 were thermophilous teleost species, 4 unclassified and 2 belonged to cold water fauna.

DISCUSSION

Fisheries have been reported in the Lagoon of Tunis since the early Antiquity. Furthermore, El Bekri (1068) noted presence of two large farming sites in the area close to the sea (we think that they probably were rudimentary local fish-trappings, their vernacular name is '*charfia*'). Among the fish species abundantly caught in the area, he cited the striped sea bream, the gilt-head sea bream and the flat head grey mullet.

Fishermen from Lagoon of Tunis are drawn on one of the large tapestries carried out in order to commemorate Tunis taken by Charles the Fifth. Peyssonnel (1724), given a thorough description of the rudimentary fish-trappings, probably *charfia*, also named '*bordigou*' or '*peschiere*' used at the beginning of the 18th century.

Further, new fishing gears were introduced, such as fish-trappings, gill-nets, chest-nets and cast-nets (Chamfrault, 1955), and for eels exclusively, a passive fishing device, the '*capéchade*', derivative of a hoop net (Quignard & Farrugio, 1981).

Between 1896 and 1958, fisheries were regulated by grants in order to improve their economical productivity (Fagès & Ponzeverra, 1908). However, since 1958, the Office National des Pêches de Tunisie (ONP) controlled both exploitation and commercialization of the lagoon production. At present, the ONP no longer exists; the fish-trappings were removed and fishing is not supported by statistical data.

Tab. 1: List of the three categories of teleost species recorded in Tunis Southern Lagoon. *: species recorded for the first time in the area; (A): abundantly caught throughout the year; (C): commonly caught throughout or in one or some periods of the year; (R): rarely caught in one or some period of the year; (O): occasionally caught; (AM): Atlanto-Mediterranean; (Cm): cosmopolitan; (E): endemic; (CWF): cold water-fauna; (TS): thermophilous species; (U): unclassified.

Tab. 1: Seznam treh kategorij kostnic, zabeleženih v Tuniški južni laguni. *: vrsta zabeležena prvič v tem območju; (A): ujeta v velikem številu skozi vse leto; (C): ujeta skozi vse leto ali le v nekaterih letnih obdobjih; (R): redko ujeta v enem ali v nekaterih letnih obdobjih; (O): občasno ujeta; (AM): atlantsko-sredozemska; (Cm): kozmopolitska; (E): endemična; (CWF): mrzloljubna favna; (TS): toploljubna vrsta; (U): neopredeljena.

Sedentary species	**Marine species**	**Regular migratory species**
Aphanius fasciatus (R, E, U)	*Anguilla anguilla* (C, AM, CWF)	*Balistes carolinensis* * (R, AM, TS)
Atherina boyeri (C, AM, U)	*Mugil cephalus* (C, Cm, TS)	*Diplodus puntazzo* * (R, AM, TS)
Gobius níger * (A, AM, U)	*Chelon labrosus* (C, AM, U)	*Sardinella aurita* * (R, AM, TS)
Zosterisessor ophiocephalus * (R, E, TS)	*Liza aurata* (C, AM, U)	*Spicara flexuosa* * (R, AM, U)
Salaria basilica * (A, E, U)	*L. ramada* (C, AM, U)	*S. meana* * (R, AM, U)
Labrus mixtus * (R, AM, U)	*L. saliens* (C, AM, U)	*Bothus podas podas* * (R, AM, TS)
Symphodus cinereus * (R, AM, TS)	*Zeus faber* * (C, AM, TS)	*Epinephelus marginatus* * (R, AM, TS)
S. melops * (R, AM, TS)	*Scorpaena porcus* * (A, AM, TS)	*Merluccius merluccius* * (C, AM, CWF)
S. tinca * (R, AM, TS)	*Dicentrarchus labrax* (C, AM, U)	*Pagellus erythrinus* * (C, AM, CWF)
Hippocampus hippocampus * (C, AM, TS)	*Lithognathus mormyrus* (C, AM, TS)	*Pagrus auriga* * (R, AM, TS)
H. guttulatus * (C, AM, TS)	*Sparus aurata* (C, AM, TS)	*Pomatomus saltatrix* * (O, AM, TS)
Syngnathus acus * (C, AM, U)	*Diplodus annularis* * (A, AM, TS)	*Sardina pilchardus* * (C, AM, TS)
S. typhle * (C, AM, U)	*D. vulgaris* * (C, AM, TS)	*Scomber scombrus* * (C, AM, TS)
	D. sargus * (C, E, TS)	*Symphodus ocellatus* * (O, E, TS)
	Sarpa salpa (C, AM, TS)	*Trachinotus ovatus* * (O, AM, U)
	Boops boops * (C, AM, TS)	*Trigla lucerna* * (R, AM, U)
	Belone belone * (C, AM, U)	*Labrus merula* * (R, AM, TS)
	Solea vulgaris (C, AM, U)	*L. viridis* * (R, AM, TS)
	S. senegalensis * (C, AM, TS)	*Conger conger* * (R, AM, TS)
	Mullus barbatus * (C, AM, TS)	*Gobius gobitis* * (R, AM, TS)
	M. surmuletus * (C, AM, TS)	*Umbrina cirrosa* * (C, AM, TS)
	Sphyraena sphyraena * (C, AM, TS)	*Dentex dentex* * (R, AM, TS)
	Trachurus trachurus * (C, AM, TS)	*Dactylopterus volitans* * (R, AM, TS)
	Sardinella maderensis * (C, AM, TS)	
	Serranus scriba * (R, AM, TS)	
	Engraulis encrasicholus * (C, AM, U)	

Zaouali (1988) globally considered three historical phases in the development of fisheries in the Lagoon of Tunis. During the first phase, lasting between the partition of the lagoon in two areas, 1895 and 1920 approximately, fishery production focused on species of economic interest, but the targeted species was the gilthead sea bream. During the second phase, from 1920 to the beginning of the eighties, mullets were the most captured qualitatively and quantitatively. During the third phase concomitant to the degradation of the ecosystem, the fisheries production mainly comprised eels. An analysis of flesh removed from some fish species showed high values of heavy metals (see Ben Souissi *et al.*, 2000; Ben Souissi, 2002). So, constant decline of fishery production was observed, and a comparative study showed that it reached 250 tons in 1928 (Chamfrault, 1955) against 18 tons in 1995 (ONP, *unpubl. data)*.

With special regard to the species recorded in Tunis Southern Lagoon, Zaouali (1988) noted that the available data are based on check-lists, which mainly reported commercially interesting species. Of the 14 species recorded in Tunis Southern Lagoon, two were sedentary and 12 were regular migratory species; no marine species were recorded. The first category comprised small size species not included in statistical reports.

A significant increase of fish species reported after the environmental restoration of Tunis Southern Lagoon appears in Table 1. Formerly, the area exhibited a low fish biodiversity as the consequence of heavy pollution. At present, the significant increase in fish biodiversity shows that the area is submitted to the influence of marine flux.

The ichthyological investigation showed that of the 62 species identified in the area, 48 were recorded for the first time in Tunis Southern Lagoon, with all the marine and most of the regular migratory species, especially elasmobranch species, among them (see Table 1). They are included among the 160 teleost species reported in the Gulf of Tunis (Bradaï *et al.*, 2004).

Most of the recorded species were Atlanto-Mediterranean, and only some of them were endemic, which confirms the role of the nearby Gulf of Tunis in population settlement of Tunis Southern Lagoon. However, most of the recorded species were thermophilous and generally found in warm water, although temperature of Tunis Southern Lagoon did not increase significantly. The relative abundance of these species is possibly due to fact that the waters of the Gulf of Tunis are probably becoming warmer, the same as in other Mediterranean areas (see Francour *et al.,* 1994). By contrast, the occurrence of cold water species shows that several species took refuge in a restricted but also protected area, probably for trophic relations, such as *Sphyraena sphyraena*, *Trigla lucerna*, *Dentex dentex* and *Dactylopterus volitans*, which are generally found in deeper waters.

In Table 2, the number of species recorded in some perimediterranean lagoons is summarized. The ichthyological specific richness, observed in Tunis Southern Lagoon due to the recent fishes' intrusion in the area, confirms the success of the environmental restoration of the area. Moreover, it is interesting to point out a significant decrease of fish species in the Lagoon of Ghar El Melh. Between 1985 and 1995, Rhomdane (1985) recorded 49 and Ach-Ben Fadhel (1995) 38 species, 11 species disappeared from the area, including three elasmobranch species, which are rarely found in lagoons (see Capapé *et al.*, 2004; Méjri *et al.*, 2004). This difference is not due to sampling but to the fact that at the lagoon is subjected to pollution pressures, similar to those

Tab. 2: Ichthyological specific diversity observed in perimediterranean lagoons.
Tab. 2: Ihtiološka specifična pestrost v obmediteranskih lagunah.

Lagoon	Area	No. species	Authors
Gruissan	South. France	12	Gourret (1897)
Canet	South. France	13–15	Gourret (1897); Hervé (1978)
Méjean	South. France	14	Paris & Quignard (1971)
Prévost	South. France	14–31	Gourret (1897); Paris & Quignard (1971); Favry *et al.* (1998)
Pierre-Blanche	South. France	15–29	Paris & Quignard (1971); Le Corre & Autem (1982)
Bages-Sigean	South. France	18-22	Gourret (1897); Cahet *et al.* (1974)
Frontignan	South. France	19	Paris & Quignard (1971)
Lapalme	South. France	19–29	Gourret (1897); Cambrony (1984)
Salses-Leucate	South. France	25–27	Gourret (1897); Hervé (1978)
Ayrolle-Campignol	South. France	29	Gourret (1897)
Bourdigou	South. France	32	Cambrony (1984)
Mauguio	South. France	24–71	Quignard *et al.* (1989); Bouchereau *et al.* (1990)
Berre	South. France	38–55	Huve *et al.* (1973)
Thau	South. France	70	Paris & Quignard (1971)
Biguglia	Corsica	8	Ximenès (1980)
Urbino	Corsica	37	Ximenès (1980)
Diana	Corsica	41	Ximenès (1980)
Nador	North. Morocco	28	Guélorget *et al.* (1985)
Bizerte	North. Tunisia	30	Zaouali (1984)
Ichkeul	North. Tunisia	22	Chaouachi (1995); Chaouachi & Ben Hassine (1998)
Ghar El Melh	North. Tunisia	49	Romdhane (1985)
Ghar El Melh	North. Tunisia	38	Ach-Ben Fadhel (1995)
Bahiret El Biban	South. Tunisia	20	Lemoalle & Vidy (1984)
Tunis South. Lagoon	North. Tunisia	14	Zaouali-Laidain (1974): prior to restoration
Tunis South. Lagoon	North. Tunisia	62	Present study: post restoration

previously reported for Tunis Northern and Southern Lagoons, and will further be a subject of environmental restoration.

Moreover, in the sample, both marine and regular migratory species were qualitatively and quantitatively dominant, some species are currently and regularly caught in the area, throughout the year. Prior to the lagoon environmental restoration, no marine species were recorded in the area, moreover, for instance, *Z. faber*, to our knowledge, was recorded for the first time in a perimediterranean lagoon (Ben Souissi *et al.*, 2004).

As the water quality has been improved considerably, it enabled numerous floristic and faunistic invertebrate communities to reproduce and develop in the area (Ben Souissi, 2002; Ben Souissi *et al.*, 2003). So, their availability constitutes the main ecological support for further development of fish species. Moreover, among the specimens captured in the area, many of them were juveniles, and these findings suggest that some species could develop and reproduce in the area (see Ben Souissi *et al.*, 2004).

The success of a definite establishment of fish populations remains speculative. Intrusion of some species is fortuitous. Fish overlaps, which involve further competition pressures, cannot be excluded. The present observations on fish communities are based on small samples and are not sufficient to provide an estimate of their absolute abundance. Moreover, migrations outside and inside the lagoon demand the greatest possible attention, especially further works in population dynamics.

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KOSTNICE, UGOTOVLJENE V TUNIŠKI JUŽNI LAGUNI PO NJENEM OKOLJSKEM RESTAVRIRANJU (JUŽNO SREDNJE SREDOZEMLJE)

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POVZETZEK

Med raziskavami, opravljenimi po okoljskem restavriranju Tuniške južne lagune nedaleč od Tuniškega zaliva, je bilo zabeleženih 62 vrst pravih kostnic, 48 med njimi prvič v tem območju. Med vsemi 62 kostnicami je bilo 13 sedentarnih, 26 morskih in 23 rednih selečih se vrst. Avtorji v pričujočem članku razpravljajo o njihovem pojavljanju v raziskovanem območju.

Ključne besede: Osteichthyes, kostnice, okoljsko restavriranje, Tuniška južna laguna, Tunizija, osrednje Sredozemlje

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NEW CONTRIBUTIONS TO THE MARINE COASTAL FISH FAUNA OF SLOVENIA

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ABSTRACT

Seven new records of marine fish fauna have been reported for Slovenia: Pteroplatytrigon violacea, Gobius roulei, Pomatoschistus bathi, Millerigobius macrocephalus, Thorogobius ephippiatus, Apletodon incognitus *and* Parablennius zvonimiri. *Additional information on the occurrence of certain less known species, such as* Labrus viridis *and* Clinitrachus argentatus, *are presented. The majority of fishes have been recorded by the use of new techniques, associated with the SCUBA equipment. These underwater techniques allowed us to observe, photograph and sometimes even catch certain fish species, which had not been normally detected with the use of traditional fishing gear due to their rarity or specific cryptic habitat type in which they live.*

Key words: coastal ichthyofauna, first records, Gulf of Trieste, Adriatic

NUOVI CONTRIBUTI ALLA FAUNA ITTICA COSTIERA IN SLOVENIA

SINTESI

L'articolo riporta la presenza di sette nuove specie per la fauna ittica marina in Slovenia: Pteroplatytrigon violacea, Gobius roulei, Pomatoschistus bathi, Millerigobius macrocephalus, Thorogobius ephippiatus, Apletodon incognitus *e* Parablennius zvonimiri. *Gli autori inoltre forniscono nuove informazioni riguardo alla presenza di specie poco conosciute, quali* Labrus viridis *e* Clinitrachus argentatus. *La maggior parte degli esemplari è stata campionata con l'ausilio di nuove tecniche subacquee. Tali metodologie permettono di osservare, fotografare e alcune volte catturare specie ittiche che non verrebbero campionate con le tradizionali tecniche di pesca, vista la loro rarità o l'habitat criptico specifico nel quale vivono.*

Parole chiave: ittiofauna costiera, prime segnalazioni, Golfo di Trieste, mare Adriatico

INTRODUCTION

Despite the fact that the marine ichthyofauna has been relatively well investigated in the Adriatic Sea, the Gulf of Trieste remains one of the poorly studied areas. The knowledge about the marine fish fauna inhabiting the Slovenian coastal sea, *i.e.* the southern part of the Gulf, is therefore rather scarce. Only few reports exist on the Slovenian marine ichthyofauna and even these deal only with specific aspects, such as the list of fish species presented by Matjašič *et al.* (1975), demersal fish resources (Štirn & Bolje, 1989; Bolje, 1992; Marčeta, 1996), and some new records of fish species (Lipej *et al.*, 1996; Dulčić & Lipej, 1997). The checklist of all so far reported species can be found in the *Key for the determination of vertebrates of Slovenia* (Kryštufek & Janžekovič, 1999). In this particular work, Lipej (1999) states 23 species of elasmobranchs, and Marčeta (1999) 219 species of Osteichthyes (24 of them were defined as expected). Since then, no works of this kind have been published.

The aim of this paper is to present information on some new fish species, recorded for the very first time in Slovenian territorial waters, and some additional data on some rare or less known fish species currently treated as rare.

MATERIAL AND METHODS

The geographical area concerned in this study includes the southern part of the Gulf of Trieste (northern Adriatic Sea). During the comprehensive surveys of marine ichthyofauna in Slovenian coastal waters, certain fish species were caught or at least observed.

Information on the occurrence of studied species originates from: i) from visual census techniques *(e.g.* Lipej *et al.*, 2003; Orlando Bonaca & Lipej, 2005), ii), sampling of cryptobenthic species, iii) occasional catches, and iv) selective searching for particular coastal fish groups such as blennioids, gobiids or gobiesocids. During the spring-summer months from 1998 to 2005, 63 vertical transects, 100 horizontal transects, 48 all-occurrence samples and 48 linear cinetransects were performed at different along the Slovenian coast in order to assess the coastal fish assemblage. Cryptobenthic species were collected beneath stones and in crevices using a narcotizing solution of quinaldine. All collected specimens are housed in the collection of the Marine Biology Station Piran.

RESULTS AND DISCUSSION

In this paper we report on the occurrence of six new fish species for Slovenian territorial waters, which had previously not been reported or defined as expected by Marčeta (1999) and Lipej (1999) in their key to the determination of marine fishes of Slovenia. We have also data on the occurrence of 2 rare and poorly known species from Slovenian coastal waters. *Millerigobius macrocephalus* and *Gobius roulei* had been previously already reported by Lipej *et al.* (2003) and Orlando Bonaca & Lipej (2005), *i.e.* in the papers dealing with the coastal fish assemblage and factors affecting habitat occupancy, assessed by means of visual methods.

***Pteroplatytrigon violacea* (Bonaparte, 1832)**

Syn. *Dasyatis violacea* Bonaparte, 1832

Jardas (1996) listed *Pteroplatytrigon violacea* as a very rare species for the Adriatic Sea. The pelagic stingray has been noticed only recently in the Gulf of Trieste (Fig. 1). A note on the feeding habits of this species with some data on its occurrence has been published by Mavrič *et al.* (2004). Between May and September 2004, nine specimens were caught in Slovenian coastal waters off Piran. In September 2005, more than 30 pelagic stingrays were caught in the same waters. The pelagic stingray has been seen entering the Gulf of Trieste only recently, for during the intensive 10-year monitoring of fisheries in Slovenia it had not been recorded at all (Marčeta, *pers. comm.).*

***Gobius roulei* De Buen, 1928**

Fiesa, 23 Jun 2000, 1 specimen; Portorož, 27 Jul 2000, 1 specimen; Portorož, 3 Aug 2000, 1 specimen; Cape Madona, 4 Aug 2000, 1 specimen; Cape Madona, 7 Aug 2000, 1 specimen; Moleto, 11 Aug 2000, *Posidonia oceanica* meadow, 1 specimen; Fiesa – Pacug, 18 Aug 2000, 1 specimen; Piran – under the church, 13 Jul 2001, *Cystoseira barbata* algal belt, 2 specimens, depth range 2–3 m; Moleto, *Posidonia oceanica* meadow, 3 Aug 2001, 2.5 m depth (Turk *et al.*, 2002); Fiesa, 24 Aug 2005, 2 specimens, depth range 6.3–6.4 m.

The very first record of Roule's goby for the Adriatic Sea was made in the infralittoral zone of the Kvarner area (Kovačić, 1995). In Slovenian coastal waters, this goby has been documented in the sandy patches of the upper infralittoral belt. The preferred habitat type is similar to that described by Kovačić (1995): sandy ground without vegetation in the biocoenosis of photophilic algae. We have never observed it on the rocky bottom. In the Slovenian part of the Adriatic Sea, it should be given the status of a rather common species (Fig. 2).

***Pomatoschistus bathi* Miller, 1982**

Pacug, 24 May 2001, *Cystoseira barbata* algal belt, 3 specimens, 2–3 m depth*;* Piran – below the church, 13 Jul 2001, infralittoral algal belt, 3 specimens, depth range 2–3 m; Pacug, 17 Aug 2001, *Cystoseira barbata* algal belt, 1 specimen; Strunjan – Salinera, 20 Aug 2001, *Cymodocea nodosa* meadow, 1 specimen,

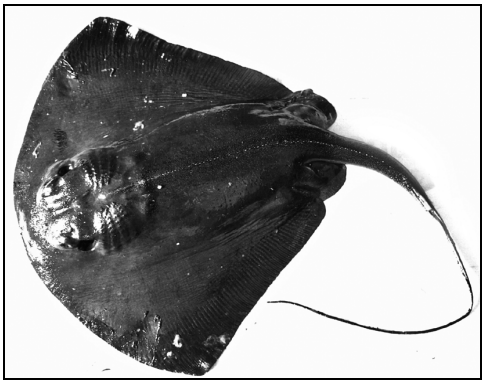

Fig. 1: Pelagic stingray *(Pteroplatytrigon violacea)***. *(Photo: L. Lipej)***
Sl. 1: Vijoličasti morski bič *(Pteroplatytrigon violacea).* ***(Foto: L. Lipej)***

Fig. 2: Roule's goby *(Gobius roulei)* ***has been ascertained as a new goby species for the Slovenian fauna. (Photo: T. Makovec)***
Sl. 2: Roulejev glavač *(Gobius roulei)* ***je nova vrsta glavača v slovenski favni. (Foto: T. Makovec)***

Fig. 3: *Pomatoschistus bathi* ***is a common species of littoral gobies in Slovenian coastal waters. (Photo: T. Makovec)***
Sl. 3: Bathijev glavaček *(Pomatoschistus bathi)* ***je pogosta vrsta obrežnih glavačev v slovenskem morju. (Foto: T. Makovec)***

Fig. 4: *Millerigobius macrocephalusis* ***is a cryptobenthic gobiid species, relatively common in the Slovenian sea. (Photo: T. Makovec)***
Sl. 4: *Millerigobius macrocephalusis* ***je kriptobentoška vrsta glavača, razmeroma pogosta je v slovenskem morju. (Foto: T. Makovec)***

Fig. 5: *Thorogobius ephippiatus****, photographed at 9 August 2005 off Cape Madona. (Photo: M. Richter)***
Sl. 5: *Thorogobius ephippiatus****, fotografiran 9 avgusta 2005 v naravnem spomeniku Rt Madona. (Foto: M. Richter)***

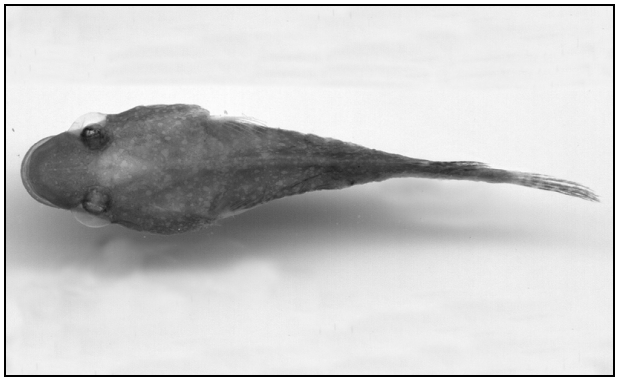

Fig. 6 / Sl. 6: *Apletodon incognitus.* ***(Photo / Foto: T. Makovec)***

Fig. 7 / Sl. 7: *Labrus viridis.* ***(Photo / Foto: M. Richter)***

depth range 2,5–3 m; 23 Aug 2001, Nature Monument Debeli rtič, infralittoral algal belt, 2 specimens, depth range 1–2 m; Fiesa, 24 Aug 2005, 4 specimens, depth range 3–3.4 m; Fiesa, 23 Sept 2005, 1 specimen, depth 4.2.

According to Jardas (1996), this species has been recorded only in the Central Adriatic. Recently, Kovačić (2005) found this goby at different sites in the Kvarner Archipelago (Northern Adriatic), as well as in the Central and Southern Adriatic. This species is missing in the Key of Marčeta (1999). In the 1998–2005 periods, we recorded *P. bathi* almost at every investigated locality in Slovenian coastal waters (Fig. 3). The species showed a high preference for gravel and coarse sand. Its distribution may depend mainly on the avoidance of surf wave action near the surface down to 5 m depth (Zander, 1990). To this end, *P. bathi* should be considered as a rather common gobiid species, very abundant in sandy patches of the upper infralittoral belt of the Slovenian coast.

Clinitrachus argentatus **(Risso, 1810)**
Syn. *Cristiceps argentatus* (Risso, 1810)

Koper, 20 Sept 2004, 1 specimen, 1 m depth, g. V. Žiža.

In the survey of blennioids inhabiting Slovenian coastal waters, Lipej & Richter (1999) reported on the occurrence of two specimens of *Clinitrachus argenteus* at a depth range of 0.1–0.5 m. However, they mentioned that they failed to catch or at least to photograph the specimens. A specimen of *Clinitrachus argentatus* was caught at a pier in the Koper harbour by the use of hand-net for smelt *(Atherina hepsetus).*

Millerigobius macrocephalus **Bath, 1973**

Bernardin, 3 Aug 2000, 3 specimens, 2 m depth; Pacug, 1 Aug 2001, *Cystoseira barbata* algal belt, 2 specimens, 2 m depth*;* Moleto, *Posidonia oceanica* meadow, 3 Aug 2001, 2.5 m depth (Turk *et al.*, 2002); Pacug – Salinera, 17 Aug 2001, 4 specimens, depth range 2.5–4 m; Strunjan – Salinera, 20 Aug 2001, *Cymodocea nodosa* meadow, 2 specimens, depth range 2.5–3 m; Piran – below the church, 27 Aug 2001, crevices of the precorallligenous belt, 2 specimens, depth range 5–6 m; Salinera, 11 Sept 2001, a single specimen in the upper infralittoral belt; Bernardin, 31 Aug 2005, 6 specimens, depth range 2.9–4.6 m; Bernardin, 27 Sept 2005, 9 specimens in a Cystoseiretum association, 2.4–3.2 m.

According to Jardas (1996), the data on this cryptobenthic gobiid species are very scarce in the Adriatic Sea. The localities, where this species has been recorded, include Brač Island, Medulin and Limski kanal. Kovačić (2005) reported on additional new sites from Šolta Island and the Central Adriatic. Marčeta (1999) defined it as an expected species for Slovenian coastal waters. *M. macrocephalus* has been already referred to in the two specific fish fauna surveys in the *Posidonia oceanica* meadow (Turk *et al.*, 2002) and in the comparative study of coastal ichthyofauna in marine protected areas (Lipej *et al.*, 2003). *M. macrocephalus* has been recorded at several localities in Slovenian coastal waters, mainly in the upper infralittoral belt, where it was found in endolithic holes (Fig. 4). Most of the specimens were collected under stones, while some specimens were caught by spraying quinaldine in the holes of endolithic bivalve *L. lithophaga*.

Thorogobius ephippiatus **(Lowe, 1839)**

Thorogobius ephippiatus has been documented at various localities in the Northern Adriatic, but not in the Gulf of Trieste. A single specimen was observed on 9 Aug 2005 in a rocky environment encrusted with coralligenous algae within Cape Madona Nature Monument off Piran. The goby was subsequently photographed (Fig. 5) in

a sheltered cavity beneath sandstone rocks at 10 m depth. It was a juvenile, approximately 6 to 7 cm in total length.

Apletodon incognitus Hofrichter & Patzner, 1997

Piran – below the church, 10 May 2000, 1 specimen; Moleto, 14 Aug 2000, 3 specimens in a habitat type close to *Posidonia* seagrass meadow at depth 2,5–3m; Bernardin, 5 Oct 2000, 1 specimen; Strunjan – Salinera, 20 Aug 2001, *Cymodocea nodosa* meadow, 1 specimen, depth range 2.5–3 m.

Recently, Hofrichter & Patzner (1997) described a new gobiesocid species *Apletodon incognitus* from the Mediterranean and Atlantic Seas. This species is missing in the Key of Marčeta (1999). Most of the specimens of *A. incognitus* have been found in infralittoral belt (Fig. 6), in habitat types dominated by *C. nodosa*. This is in agreement with Patzner (1999) and Hofrichter & Patzner (2000), who stated that *A. incognitus* is associated with seagrass meadows of *P. oceanica* or suitable habitats near seagrass meadows. They even pointed out that the abundance of this clingfish species is decreasing with the increasing distance from the seagrass meadow. Most of our records were made by the use of an anaesthetic. Only on a single occasion we recorded a specimen in a vertical transect sample, where it was found under an empty crab shell *(Maja* sp.).

Labrus viridis Linnaeus, 1758

According to Jardas (1996), this wrasse is present mainly in the southern part of the Adriatic, whereas in the northern part it is quite rare. During the comprehensive monitoring of flora, fauna and habitat types in the coastal sea during the 1998–2004 period, this species was never observed or caught. A specimen of *Labrus viridis* (Fig. 7) was observed on 26 July 2005 off Cape Madona (Piran), in the infralittoral belt (3.5 m depth), where stones are mainly covered with the brown algae *Cystoseira barbata*. A specimen was also photographed on 9 Aug 2005 at the same site (1.5 m depth).

Parablennius zvonimiri (Kolombatović, 1892)

Syn. *Blennius zvonimiri* Kolombatović, 1892

Cape Ronek, 18 Sept 2003, 2 specimens, depth range 2.6–2.8 m; in front of the Marine Biology Station Piran, 23 Aug 2005, 1 specimen, 1.4 m depth; Bernardin harbour, 30 Aug 2005, 7 specimens, depth range 1.2–2.5 m; Bernardin harbour, 31 Aug 2005, 4 specimens, depth range 2.1–3.3 m; Cape Madona, 1 Sept 2005, 5 specimens, depth range 5.3–8.1; Cape Madona, 6 Sept 2005, 5 specimens, depth range 6.1–9.2 m; Fiesa, 12 Sept 2005, 1 specimen, 4 m depth; Pacug, 16 Sept 2005, 4 specimens, depth range 2.8–7.5 m; Fiesa, 23 Sept 2003, 1 specimen, 5.4 m depth.

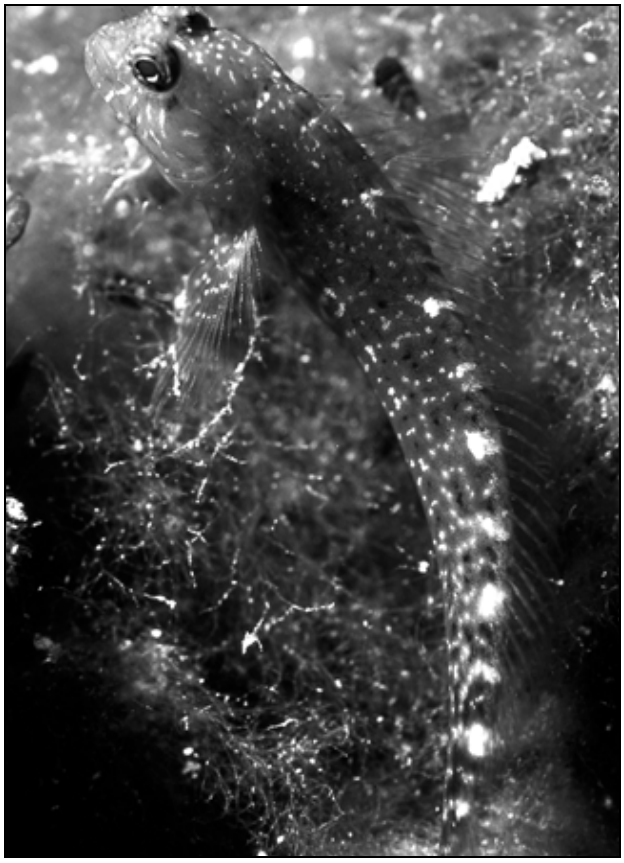

Fig. 8: *Parablennius zvonimiri* ***is an endolithic blenniid species. (Photo: T. Makovec)***
Sl. 8: Jelenjeroga babica *(Parablennius zvonimiri)* ***je endolitska vrsta babic. (Foto: T. Makovec)***

Lipej & Richter (1999) did not include this species in their survey of blennioids in Slovenian coastal waters, although they wrote that this species was an expected blenny in the area, since other authors had confirmed its occurrence in other adjacent northern Adriatic areas (Segantin, 1968; Patzner, 1985; Illich & Kotrschal, 1990). Marčeta (1999), too, described it as an expected species in Slovenian coastal waters. *Parablennius zvonimiri* has been recently recorded at several localities in these waters, in each case in a sheltered environment generally covered with algal turf and encrusted with coralligenous algae (Fig. 8), where it inhabits holes excavated by the endolithic bivalve *Lithophaga lithophaga*. In such shady biotopes it blends with the red-brownish substrata (Abel, 1993).

Factors involved in the new findings

Nowadays, new approaches and techniques, associated with the SCUBA equipment, enable exploration of otherwise inaccessible habitats (Quignard & Tomasini, 2000; Lipej & Dulčić, 2004). With these underwater

techniques we were able to observe, photograph and sometimes even catch certain fish species, which could previously not be detected with the use of traditional fishing gear due to their rarity or specific cryptic habitat type in which they live. To this end, divers need extensive training, especially for the detection of small cryptic species.

With the recently adopted SCUBA techniques, we recorded seven new elements in the Slovenian marine fish fauna. Only *C. argentatus* was caught with hand net for sand smelt *(Atherina* spp.), whereas the specimen of *L. viridis* was photographed and sighted. Due to the increasing research efforts in terms of selective sampling of peculiar fish families, such as Blenniidae and Gobiidae, we succeeded also in confirming *P. zvonimiri, Pomatoschistus bathi. G. roulei* and *T. ephippiatus*. The first three were recorded in specific habitat types at several localities. Despite *in vivo* observations, *P. bathi* has been overlooked in the past due to its small size and cryptic colouration, which reflects very well the colour pattern of its environment. *T. ephippiatus* has been observed only at a single locality. Due to its specific habitat type demands – crevices, cracks and cavities of steep rock faces, as reported by Miller (1986) – it is probable that the area off Cape Madona provides the only suitable habitat for this species in Slovenia. This unique site comprises habitat types with high spatial heterogeneity, where the detection of cryptobenthic species is even more difficult.

Certain authors have argued (*e.g.* Colterill & Dangerfield, 1997) that species' checklists without voucher specimens are pseudoscientific as their inventory identification can not be tested. In our opinion, the photographed records of certain rare species are very relevant and are in some cases even unique evidence, as it has been the case of a bramble shark *(Echinorhinus brucus),* photographed with the ROV camera below 1200 m (Kabasakal *et al.*, 2005). Photographs could be proofs for records of fish species only if species could be positively identified from their shape and coloration. For example, very small number of gobiid species could be identified in this way, and the published records based on photographs are very rare, like Ballesta *et al.* (1998) on *D. schlieweni*.

With the use of quinaldine we were able to record two more cryptobenthic species, such as *M. macrocephalus* and *A. incognitus*. This method, however, could be highly toxic for fish as well as for divers. The records of *L. viridis* and *P. violacea* seem to be correlated with temperature increase during the last decades, but further findings will elucidate the real status of both species.

The findings reached during the present study extend the already known distribution of recorded species in the Mediterranean Sea. We expect that with the use of underwater visual techniques some new fish species for the Slovenian fauna will be found during the future investigations.

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NOVI PRISPEVKI K MORSKI RIBJI FAVNI SLOVENIJE

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SUMMARY

V prispevku navajamo podatke o sedmih novih vrstah rib za favno Slovenije: vijoličasti morski bič (Pteroplatytrigon violacea), *Roulejev glavač* (Gobius roulei), *Bathijev glavaček* (Pomatoschistus bathi), *rdeči glavač* (Millerigobius macrocephalus), *leopardasti glavač* (Thorogobius ephippiatus), *prisesnik vrste* Apletodon incognitus in *jelenjeroga*

babica (Parablennius zvonimiri). *Nove podatke o pojavljanju navajamo še za dve manj znani oz. redki vrsti, in sicer za drozga* (Labrus viridis) *in srebrnico* (Clinitrachus argentatus). *Večino vrst smo vzorčili z novimi pristopi z uporabo avtonomne potapljaške opreme. Te podvodne tehnike omogočajo opazovanje in fotografiranje na mestu samem, obenem pa tudi ulov posebnih vrst rib, ki jih sicer ne moremo vzorčiti s tradicionalnim ribiškim priborom, saj so redke ali pa živijo v posebnem prikritem življenjskem okolju.*

Ključne besede: obrežna ihtiofavna, prvi zapisi, Tržaški zaliv, Jadransko morje

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SEASONALITY IN DIEL CATCH RATE OF LABRIDS IN A SHALLOW-WATER HABITAT AT DUĆE GLAVA BEACH IN THE EASTERN ADRIATIC

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ABSTRACT

An assemblage of shallow-water fishes was sampled with a small beach seine monthly, during 24-hour periods, between April 2000 and March 2001 at the sandy Duće Glava beach in the eastern Adriatic. Monthly sets of samples were divided into day and night catches to examine the stability of diel differences in assemblage structure over a one-year period. A total of 284 Labrids, mainly juveniles, representing 6 species (Symphodus ocellatus, S. cinereus, S. roissali, S. rostratus *and* Labrus viridis, L. merula) *were sampled during the whole investigation period. Each of these Labrid species had a different pattern of diurnal and seasonal abundance.* S. ocellatus *was the dominant species throughout the year. The highest increases in number of all* Symphodus *species were recorded in the summer period.* L. viridis*, represented by the largest individuals of all sampled Labrids, were not found during the summer and autumn months.* S. ocellatus, S. roissali *and* S. rostratus *appeared to be mainly diurnal, while at night more* S. cinereus *and* L. viridis *individuals were caught.*

Key words: seasonality, day/night differences, Labrids, Adriatic Sea, coastal area

STAGIONALITÀ DI CATTURE GIORNALIERE DI LABRIDI DI ACQUE POCO PROFONDE IN MARE ADRIATICO

SINTESI

*Una comunità ittica di acque poco profonde è stata campionata mensilmente per 24 ore, con l'ausilio di una piccola rete da pesca, tra aprile 2000 e marzo 2001, lungo la costa sabbiosa Duće Glava nell'Adriatico orientale. I campioni mensili sono stati divisi in catture diurne e notturne, al fine di esaminare la stabilità delle differenze giornaliere nella struttura della comunità, durante il periodo di un anno. Un totale di 284 labridi, in prevalenza stadi giovanili di 6 specie (*Symphodus ocellatus, S. cinereus, S. roissali, S. rostratus, Labrus viridis *e* L. merula*), sono stati campionati durante l'intero periodo di studio. Ognuna di queste specie di labridi ha mostrato di avere un andamento diverso dell'abbondanza giornaliera e stagionale.* S. ocellatus *è stata la specie dominante durante tutto l'anno. L'incremento maggiore nel numero di specie di* Symphodus *si è registrato durante il periodo estivo.* L. viridis*, rappresentato dagli esemplari più grandi fra tutti i labridi campionati, non è stato trovato durante l'estate e l'autunno.* S. ocellatus, S. roissali *e* S. rostratus *sono apparse specie prevalentemente diurne, mentre la gran parte degli individui di* S. cinereus *e* L. viridis *è stata catturata durante la notte.*

Parole chiave: stagionalità, differenze giorno/notte, labridi, mare Adriatico, area costiera

INTRODUCTION

Several studies have emphasized the role of marine shallow-water habitats (Thiel *et al.*, 1995; Biagi *et al.*, 1998; Nash & Santos, 1998; Guidetti & Bussotti, 2000) as nurseries of a variety of marine fishes. It has been shown that fish assemblage changes over diel periods (Nash, 1986; Wright, 1989; Nash *et al.*, 1994) due to the net avoidance during the daytime (McCleave & Fried, 1975) also due to the real changes in abundance and the assemblage structure (Lasiak, 1984; Nash *et al.*, 1994). Moreover, there is a seasonal change in the species composition, which is also reflected in the diel variations in assemblage structure (Nash, 1986; Wright, 1989).

Only a limited number of previous studies have examined the day/night catches for a whole year (Allen *et al.*, 1983; Nash & Santos, 1998; Dulčić *et al.*, 2004). Diel changes in assemblage composition, which are then superimposed on seasonal changes, could have a profound effect on the perception of a fish assemblage. The diel periodicity of an assemblage, or even the lack of periodicity, is caused by changes in catch of the individual species (Nash & Santos, 1998).

Wrasses (the family Labridae) are the most abundant and conspicuous fishes on tropical reefs around the world (Choat & Bellwood, 1998). They also comprise an important element of the coldwater fish population in temperate areas, such as Adriatic Sea, and can be found in a wide variety of habitats (Jardas, 1996). Wrasses appear in a diverse range of colours, shapes, and sizes, often varying considerably within species. They belong to the productive and low trophic level species with high ecological efficiency (Dulčić *et al.*, 1997; Wainwright & Bellwood, 2002). Many wrasses are organized into harem-based social systems and hermaphroditism is common (Choat & Bellwood, 1998).

Eighteen species from the Labridae family are found in Adriatic Sea (Jardas, 1996). The *Symphodus* spp. is one of the most abundant genera of Adriatic Labrids, while other species are rarely encountered. Although these species are not commercially interesting, they occupied considerable place in the Adriatic ichthyofauna due their pronounced biodiversity. Labrids are of tropic origin, but due to climate change, future appearance of new Labrid species, together with the increasing abundance of present Labrids as well as their movement to the northern parts of the Adriatic Sea, is expected (Dulčić & Grbec, 2000).

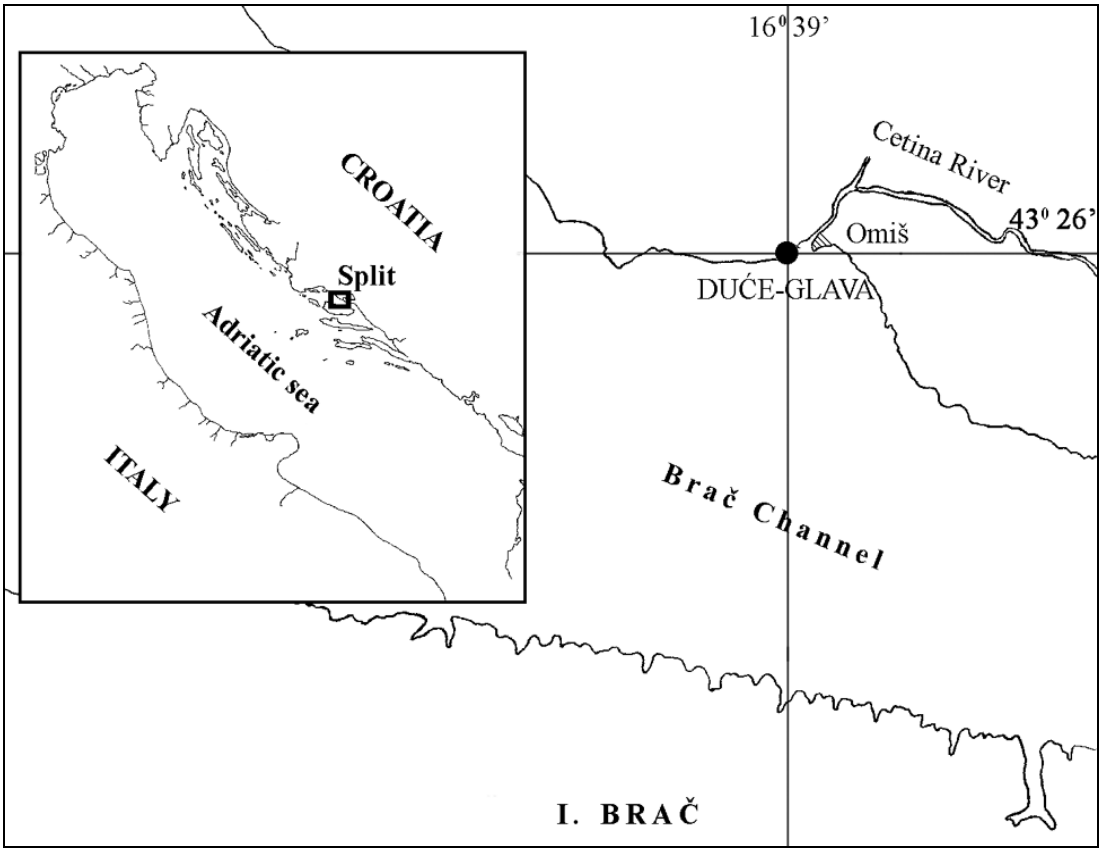

Fig. 1: Map showing the area of Duće-Glava Bay and the Cetina estuary.
Sl. 1: Zemljevid z zalivom Duće Glava v ustju reke Cetine.

This study analyses the day/night changes in catches of shallow-water Labrids over one year period and provides: 1) a description of temporal and seasonal fluctuations of Labrids in a shallow-water with mixed habitats, and 2) a comparison with other subtropical and temperate studies. Results obtained in this study could be useful for gaining a better understanding of Labrid fish community structure in the coastal Adriatic area.

MATERIAL AND METHODS

Duće Glava is a small south-facing sand beach on the Croatian Adriatic coast (approximately 20 km south of Split) near the Cetina river estuary (Fig. 1). The sampling area was sandy and partially overgrown with meadows of *Posidonia oceanica*. The beach is a popular swimming area during the summer.

Samples were collected monthly for 11 consecutive months (April 2000-March 2001). Due to exceptionally bad weather, sampling was not possible in January 2001. Each month, 7 samples were taken at 4-hour intervals with a 22 m beach seine (wings of 7.5 m and central collecting area of 7 m, 4 mm stretch size mesh at the wings reducing to 2 mm in the centre) at depths from 0.1 to 1.5 m. Before each sample, water temperature was measured and is presented as the average of the 7 measurements taken in each 24-hour sampling period. Each sample represents two sets of the net. Temperature was measured with a mercury thermometer, salinity with a laboratory inductive salinometer before each sampling.

Fish were immediately preserved in 4% formaldehyde and identified using Jardas (1996). The total number of individuals and total weight for each species in each haul was obtained. Total lengths (to the nearest 0.1 mm) and individual weights (to the nearest 0.01 g) were measured for each sample. Juvenile fishes were defined as specimens with already formed scales, and were taken as such until the moment of first sexual maturity (Katavić, 1984).

The fish data were analysed using the PRIMER software package (Plymouth Marine Laboratories, UK; Clarke & Warwick, 2001). Data were transformed for presence/absence and the Bray-Curtis similarity matrix was used to generate 2-dimensional ordination plots with the non-metric multidimensional scaling (nMDS) technique (Clarke, 1993). ANOSIM test for the two-way crossed analysis was used for testing differences in species assemblage between seasons and hours (Clarke & Warwick, 2001). Probability value was set at 0.05. Species presented in total sample with less than 5% were omitted from this analysis.

RESULTS

Mean daily temperature over the year (2000-2001) ranged from 12.3 ^{0}C in February 2001 to 23.0 ^{0}C in July 2000, while salinity ranged from 27.7 in February 2001 to 35.3 in July 2000.

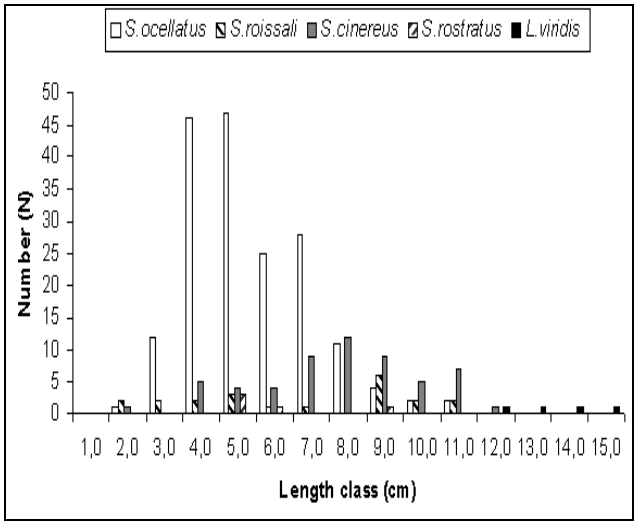

Fig. 2: Labrid representation among length classes at Duće, Adriatic coastal area.
Sl. 2: Ustnače zaliva Duće, razvrščene po različnih velikostnih razredih.

Labrids comprised 284 individuals (1.6%) of total catch (17,414 fish representing 61 species). The Labrid species were: *Symphodus ocellatus* (68.2% of total Labrids), *Symphodus cinereus* (20.1%), *Symphodus roissali* (8.5%), *Symphodus rostratus* (1.8%) and *Labrus viridis* (1.4%). Also, one individual of *Labrus merula* (L_t = 6.7 cm; W_t = 4.04 g in June at midnight) was found but is, as a single specimen, omitted from further analysis. A Labrid representation among length classes is presented in figure 2. Mostly, *S. ocellatus* individuals belong to middle-length classes from 4.0 to 7.0 cm. S. roissali were uniformly distributed through different length classes. The higher number of longer *S. cinereus* individuals from 7.0 to 11.0 cm were recorded, while the longest individuals were those of *L. viridis* belonging in length classes between 12.0 and 15.0 cm with the mean length value of 13.9 cm.

Each of these Labrid species had a different pattern of diurnal and seasonal abundance. Number of Labrids caught per season was the highest in summer (172); it declined in autumn (57), and was the lowest in winter (14). In spring, 40 Labrids (14.1%) were sampled. *S. ocellatus* were the most dominant Labrid species (42.5%) in spring, while *S. roissali* individuals were not observed in that period. The highest increase in the number of all *Symphodus* species was recorded in the

summer period. This trend was specially pronounced for *S. ocellatus* with 193 caught specimens. *L. viridis* was not found at all during summer and autumn. Lower sea temperatures were accompanied by number declination of Labrid species in the Duće area. Seasonal variability was the highest in spring and summer, although there was a large fluctuation in the number of species between those months (Fig. 3). *S. ocellatus* individuals were dominant between April and October. Higher abundance of *S. roissali* specimens was recorded from April to August. *S. cinereus* individuals were almost uniformly distributed throughout the year. The highest number of *S. rostratus* individuals was sampled in June.

The nMDS plots of Labrid samples (Fig. 4) shows there is some difference between them in colder and warmer periods, especially during the spring and winter months. Catches of the analyzed Labrid species showed little variation during the winter. Results of the ANOSIM test for the two-way crossed analysis showed that there was a significant difference in species assemblages among seasons, although correlation was not high (ρ_{av} = 0.118, P = 0.017).

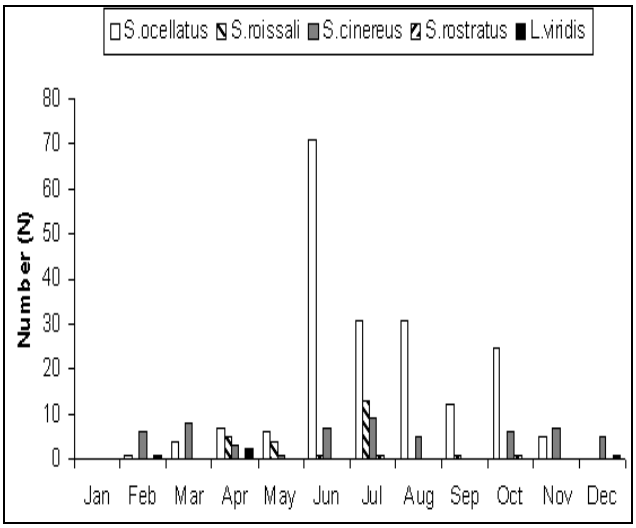

Fig. 3: Monthly distribution of Labrids at Duće, Adriatic coastal area.
Sl. 3: Mesečna razporeditev ustnač v zalivu Duće.

Over the entire year, slightly more Labrids were caught at day (152) than at night (130). With respect to the number of individuals, *S. ocellatus*, *S. roissali* and *S. rostratus* catches appeared to be mainly diurnal. On the other hand, more *S. cinereus* and *L. viridis* individuals were found in night samples. Diurnal differences in occurrence were more pronounced in *S. roissali* (16/day and 8/night) and *S. cinereus* (19/day and 38/night) species. *S. ocellatus*, as the most dominant species, was also recorded with the highest catch in each of the subsamples (Fig. 5.). *S. roissali* was not found in samples taken at midnight while, at the same time, the highest number of *S. cinereus* was recorded.

The nMDS plots of Labrid samples (Fig. 6) shows there is a clearly visible overlapping of the day and night samples. Moreover, the result of ANOSIM test for the two-way crossed analysis showed that there was no significant difference in those catches between day and night samples (ρ_{av} = 0.118, P = 0.017).

DISCUSSION

Differences in day/night composition of fish catches can have a profound effect on the perception of a fish community (Nash & Santos, 1998). Temporal variation in species abundance pointed out species separation and a partitioning of the habitat along a time axis. The advantage of this time distinguishing is reduction in competition for food and/or space and avoidance of predation (Ross, 1986).

The qualitative dominance of Sparids and Labrids and the quantitative dominance of schooling fish species in the shallow rocky Mediterranean habitats are well known (Guidetti, 2000). The preference by Labrids for substrates colonised by macroalgae has not been known only for the Mediterranean (Garcia-Rubies & Macpherson, 1995), but is a common feature in all temperate waters (Choat & Ayling, 1987). In both papers, it was affirmed that dense algal stands in shallow waters are often colonised by young Labrids, which use the algae for feeding and shelter. Moreover, Guidetti (2000) found that in the Adriatic *S. ocellatus* is one of the most common species in the *P. oceanica* seagrass beds, while *S. roissali* and *S. tinca* were mainly associated with the rocky-algal reef habitats. Structure of fish assemblages associated with some habitats, and thus occurrence of some species, is affected by a large number of interplaying and, in some cases, superimposed biological interactions *(i.e.* grazing, predation) and physical factors *(i.e.* habitat complexity, hydrodynamic forces). The differences in fish species richness and abundance are primarily related to habitat structure (Guidetti, 2000). According to fact that the area of Duće was sandy and partially overgrown with meadows of *P. oceanica*, it was expected to have more *Symphodus* species, which prefer this type of habitats, than other Labrids. The substrate type (Levin, 1991) and depth (Garcia-Rubies & Macpherson, 1995) are two main factors affecting fish recruitment, mortality and growth. Although, Letourner *et al.* (2003) found that bottom slope was generally more significant than depth. Furthermore, Letourner *et al.* (2003) suggested that benthic habitat use by fish is clearly non-random, and that differences in habitat at a small spatial scale can affect fish assemblages.

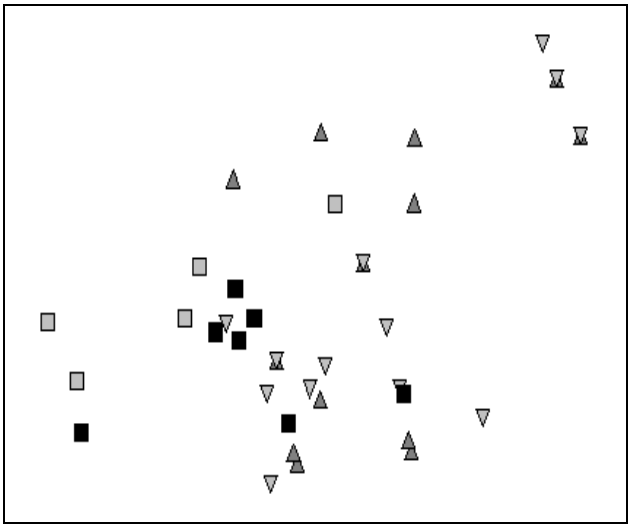

Fig. 4: Non-Metric Multidimensional Scaling (nMDS) ordination plot for Labrids during each season (stress < 0.01): ▲spring, ▼summer, ■autumn, ■winter.
Sl. 4: Nemetrično multidimenzionalno skaliranje (nMDS) za ustnače v posameznih letnih časih (pomen < 0,01): ▲pomlad, ▼poletje, ■jesen, ■zima.

Symphodus species found in the sampling area were small Labrids (cca. 10 cm), while those from *Labrus* spp. can reach lengths of up to 30 cm (Jardas, 1996). All caught specimens were in the length classes from 2.0 cm to 15.0 cm. The most frequent lengths of occurrence of the analysed Labrids are consistent with the data reported by Jardas (1996). Labrids belonged to resident species that, after metamorphosis, live permanently in the same area, where they also breed (Guidetti & Busotti, 2000; Dulčić *et al.*, 2002). Some temperate wrasse species, such as the *S. ocellatus*, *S. cinereus* and *S. rostratus*, are demersal nest builders. The nests are usually made of plant material and the male guards the eggs after they are deposited (Jardas, 1996). The time periods of occurrence of the analysed Labrid juveniles are consistent with the data reported by Dulčić *et al.* (1997). The highest abundance of all specimens was recorded during the summer (June) and the lowest during the winter (December). *S. ocellatus* were dominant Labrid species in the investigated area. Its juveniles were also one of the four dominant species in the Kornati Archipelago (Dulčić *et al.*, 1997). All species were more numerous during the summer, except *L. viridis*, which was equally found during the spring and winter periods. Discussion about *S. rostratus*, *L. viridis* and *L. merula* differences in day/night catches do not have so much sense owing to their minor percentage in total sample. One of the major reasons for such *Symphodus* spp. occurrence was in the recruitment timing of these species. Moreover, a high abundance in June and July was due to the increase of their juveniles, and this could be correlated with the spring spawning period (Jardas, 1996) and duration of embryonic development of these species (Dulčić *et al.*, 1997). It seems that in tropical wrasses spawning occurs year-round, while some temperate species obviously restrict spawning to warmer parts of the year (Choat & Ayling, 1987).

Specimens of *Symphodus* spp. were found almost during all months, but with higher abundance from June to October. Biagi *et al.* (1998) observed settlers of *S. cinereus* for only one or two months in the 0-3 m zone of the Italian costal area, and they supposed that after that they probably moved offshore to deeper waters. On the other hand, settlers of *S. rostratus* were observed at the samples for an extended period after settlement occurred (Biagi *et al.*, 1998), which is in agreement with our results. Segregation of the analysed species, in terms of reducing the possible interspecific competition for food and shelter, was not observed.

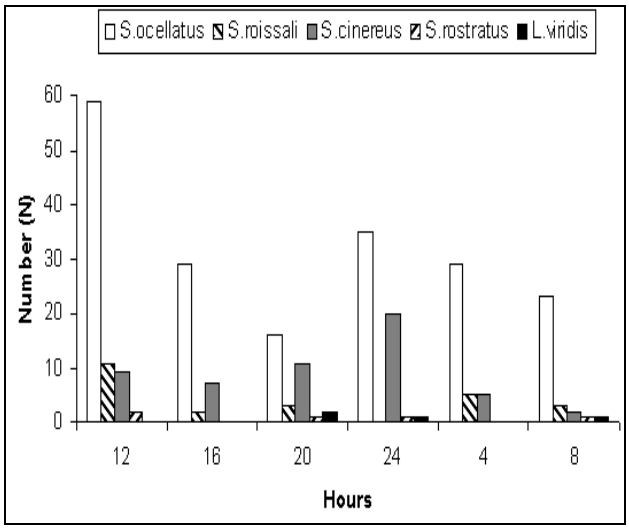

Fig. 5: Labrids representation between different sampling hours at Duće, Adriatic coastal area.
Sl. 5: Razporeditev ustnač v zalivu Duće med posameznimi urami vzorčenja.

In total, more sampled Labrids were found to be diurnal fishes. That fact is probably connected with their usage of algae for feeding and shelter during sunlight. Wrasses are strongly diurnal (only active during the daytime) and, like parrotfishes, many bury themselves in the sand or seek crevices to hide in at night (Choat & Ayling, 1987). *S. ocellatus* and *S. roissali* were mainly diurnal, while at night more *S. cinereus* specimens were found. The night occurrence could be explained as either an increased catchability at night or a movement of these individuals into the analysed area at dusk and leaving at dawn or some combination of both (Nash *et al.*, 1994). However, it is very speculative to pronounce any of those species as diurnal or nocturnal, as only with the

non-destructive method sampling we would be able to assess the real diel aspects of certain species. The highest catches were recorded by sampling in 12 h (82 individuals) and 24 h (59 individuals) periods. However, there was no significant difference in Labrid catches between day and night samples, indicating that one year of investigation is probably not enough or that more frequent sampling is needed. It is well known that the behaviour connected with the day/night light cycle differs between species and that there is often a difference in catchability or vulnerability of species relative to that point (Parsley *et al.*, 1989). In addition, individuals do not see nets at such great distances during night, and therefore capture efficiencies are higher at night. In the Mediterranean *P. oceanica* beds, Harmelin-Vivien (1982) attributed the increased abundance and diversity of the fish fauna at night not only to the immigration of nocturnal macrophagic carnivores from the adjacent reefs, but also to the movements of diurnal planktivores from the water column to the sheltered sites beneath the canopy.

It is apparent from the foregoing discussion that a number of parameters influence the differential distribution of Labrids, especially the occurrence and composition of their juveniles. Their occurrence in the Duće area is surely the result of juvenile preference for relatively shallow and nutrient rich coastal water. Also, those areas provide shelter from possible predators, whose manoeuvrability may be hampered in shallow water (Dulčić *et al.*, 1997).

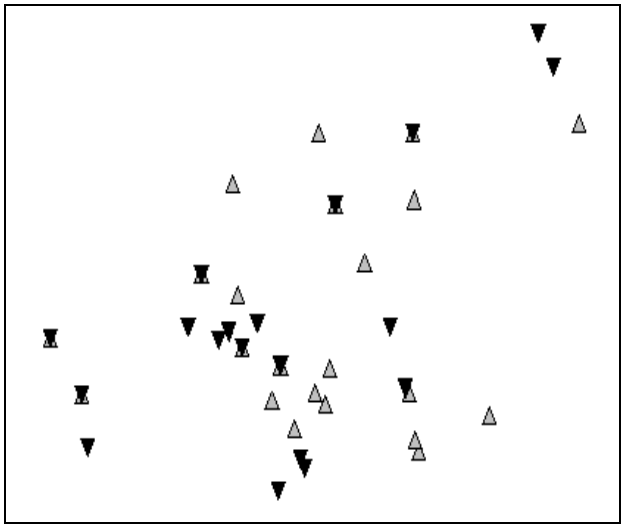

Fig. 6: Non-Metric Multidimensional Scaling (nMDS) ordination plot for Labrids among day and night samples (stress < 0.01): ▲day, ▼night.
Sl. 6: Nemetrično multidimenzionalno skaliranje (nMDS) za ustnače med dnevnimi in nočnimi vzorci (pomen < 0,01): ▲dan, ▼noč.

The results of the present study provide a basis for establishing the temporal and spatial patterns of occurrence and recruitment of the Adriatic Labrids in coastal area. It is necessary to establish their monitoring due their tropic origin, increasing abundance of the present Labrids as well as their movement to the northern parts of the Adriatic. A further research is also needed due to a reasonable expectation of new Labrid species occurring as a consequence of climate change.

SEZONSKE SPREMEMBE V DNEVNEM ULOVU USTNAČ V PLITVINAH ZALIVA DUĆE GLAVA V VZHODNEM JADRANU

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POVZETEK

Avtorji prispevka so med aprilom 2000 in marcem 2001 vzorčili združbo plitkovodnih rib, ujetih z manjšo mrežo vzdolž peščene obale Duće Glava južno od Splita (vzhodni Jadran). Z namenom, da bi preučili razlike v 24-urnem obdobju v primerjavi s strukturo združbe v enoletnem obdobju, so mesečne zbirke vzorcev razdelili na tiste, ulovljene podnevi, in tiste, ulovljene ponoči. Med celotnim preučevanim obdobjem je bilo vzorčenih 284 ustnač (z mnogimi mladostnimi osebki med njimi), pripadajočih 6 različnih vrstam (Symphodus ocellatus, S. cinereus, S. rois-

sali, S. rostratus *ter* Labrus viridis *in* L. merula). *Pri vsaki od teh ustnač je bil ugotovljen drugačen vzorec njihove dnevne in sezonske številčnosti.* S. ocellatus *je bila dominantna vrsta prek celega leta. Največji prirastki v številu vseh ustnač iz rodu* Symphodus *so bili zabeleženi v poletnem obdobju. Vrsta* L. viridis, *ki so jo zastopali največji osebki med vsemi vzorčenimi ustnačami, pa v poletnem in jesenskem obdobju sploh ni bila zabeležena. Medtem ko so bile* S. ocellatus, S. roissali *in* S. rostratus *videti predvsem dnevne ribe, je bilo ponoči ujetih največ osebkov vrst* S. cinereus *in* L. viridis.

Ključne besede: sezonskost, dnevno-nočne razlike, ustnače, Jadransko morje, obalno območje

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NEW RECORD OF SERPENT EEL *OPHISURUS SERPENS* (LINNAEUS, 1758) (OPHICHTHIDAE) IN THE ADRIATIC WATERS WITH A REVIEW OF RECENT ADRIATIC RECORDS

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ABSTRACT

On 20 July 2005, a serpent eel, Ophisurus serpens*, was caught off the island of Sv. Fumija (near Čiovo Island, eastern central Adriatic). This species is relatively rare in the Adriatic. The main morphometric data are given. A review of recent Adriatic records of this species is also presented.*

Key words: *Ophisurus serpens*, records, Adriatic Sea, morphometry

NUOVE SEGNALAZIONI DEL SERPENTE DI MARE *OPHISURUS SERPENS* (LINNAEUS, 1758) (OPHICHTHIDAE) IN ACQUE ADRIATICHE E REVISIONE DI RECENTI AVVISTAMENTI ADRIATICI

SINTESI

Il serpente di mare, Ophisurus serpens*, è stato catturato vicino all'isola di Santa Fumia (nei pressi dell'isola di Ciovo, Adriatico centro-orientale) il 20 luglio 2005. Questa specie è relativamente rara in Adriatico. L'articolo ne presenta i principali dati morfometrici. Gli autori hanno inoltre preparato una revisione dei recenti avvistamenti della specie in Adriatico.*

Parole chiave: *Ophisurus serpens*, segnalazioni, mare Adriatico, morfometria

INTRODUCTION

The serpent eel, *Ophisurus serpens* (Linnaeus, 1758), is a marine, brackish, reef-associated and benthic species living to depths of 300 m. It lives in the eastern Atlantic (northern coast of Iberian Peninsula to South Africa, also Madeira), western and middle Mediterranean, western Indian Ocean (southern Mozambique to South Africa) and western Pacific (Japan and Australasia) (Bauchot, 1986). It is very rare in the Adriatic Sea, and it lives between 30 and 400 m depth on sandy and sandy-muddy bottom (Jardas, 1996). Buried with only its head exposed (Jardas, 1996).

Data on the biology and ecology of the serpent eel in the Adriatic are very scarce. The aim of this paper is to provide first data on the morphometric characters of this species for the Adriatic and on their occurrence in the eastern Adriatic.

MATERIAL AND METHODS

Eighteen specimens of the serpent eel were caught on 20 July 2005 with long-line (by professional fisherman) off the island of Sv. Fumija (near Čiovo Island, eastern central Adriatic) (Fig. 1) at about 40 m depth on sandy bottom. One specimen was taken (Fig. 2) and others were released by the fisherman. The specimens were identified according to Jardas (1996); the chosen specimen is deposited in the Ichthyological Collection of the Institute for Oceanography and Fisheries in Split, Croatia.

The specimen was preserved in 4% buffered formaldehyde, subsequently measured to the nearest mm, and weighed to the nearest gram. Morphometric characteristics considered were total length (TL), preanal length (LPA), predorsal length (LPD), prepectoral length (LPP), dorsal fin length (Ld), anal fin length (La), pectoral fin length (Lp), body depth (H), head length (C), eye-diameter (O), interorbital length (Io), preorbital length (PO), number of pores in linea lateralis and length of lower jaw.

RESULTS AND DISCUSSION

In Table 1, the main morphometric data of the serpent eel specimen are presented.

The presented serpent eel data are the first for this species from the Adriatic Sea and in agreement with those given by Pallacio (www.fishbase.org) and Bauchot (1986). Jardas (1996) noted that maximum length for this species is TL = 2400 mm, although usual length in catch is between 500 and 1500 mm. McCosker & Castle (1986) reported that maximum length is TL = 2500 mm. The number of pores in *linea lateralis* for the specimen from the Adriatic is 202, while Jardas (1996) noted 173 pores.

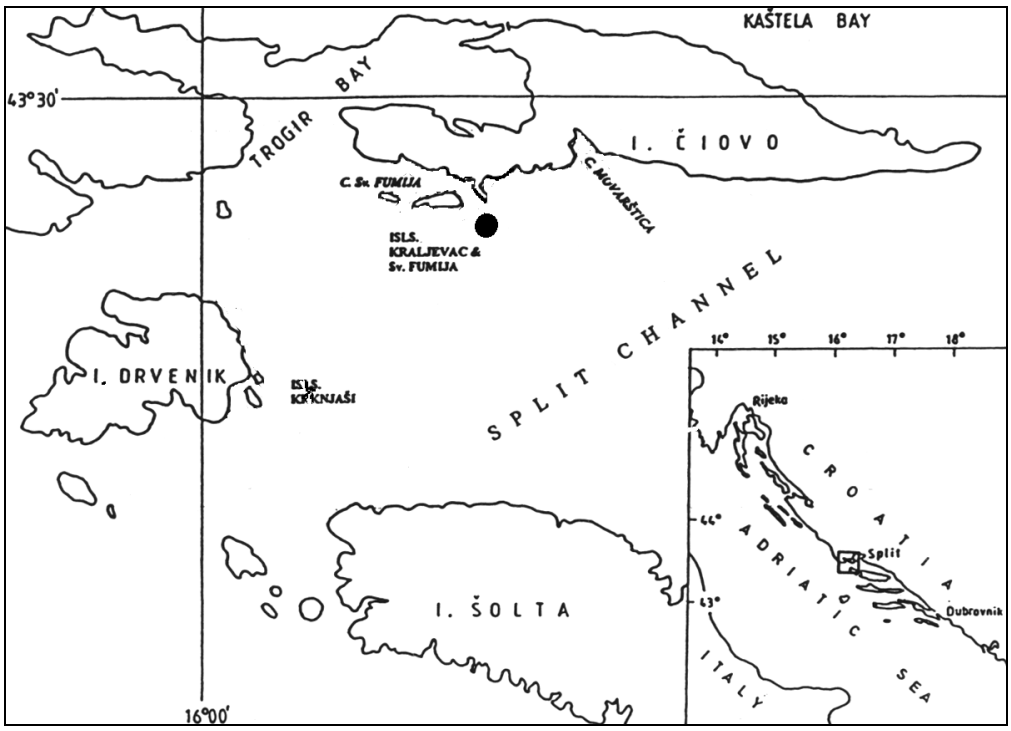

Fig. 1: Map with location of the record (island of Sv. Fumija, eastern central Adriatic).
Sl. 1: Zemljevid z lokacijo zapisa (otok Sv. Fumija, vzhodni srednji Jadran).

There have been no records of this species for the Adriatic Sea reported in scientific literature until now. In 1975, several specimens of the serpent eel were caught in the Korčula channel (no data on the number of specimens, length and weight) (Milišić, *pers. comm.*) In February 1991, a single specimen of serpent eel (TL = 2100 mm) was caught in Senjska cove (Šolta Island, eastern central Adriatic) (Milišić, 1994). Another catch (by long-line) was in March 2000 near Postira (Brač Island, eastern central Adriatic). The total length of the caught specimen was TL = 2000 mm (as reported in newspaper Slobodna Dalmacija on 29 July 2004). In November 2004, one specimen was caught near Žuljana (Pelješac Peninsula, southern Adriatic) (Milišić, *pers. comm.*).

Tab. 1: Morphometric (in mm) data of the serpent eel** Ophisurus serpens **in the eastern Adriatic.
Tab. 1: Morfometrični podatki (v mm) o zobati jegulji** Ophisurus serpens **iz vzhodnega Jadranskega morja.

Weight (g)	2500
Morphometric characters (mm)	
Total length (TL)	2130
Preanal length (LPA)	770 (36.2% TL)
Predorsal length (LPD)	220 (10.3% TL)
Prepectoral length (LPP)	160 (7.5% TL)
Dorsal fin length (LD)	1860 (87.3%)
Anal fin length (La)	1300 (61.0%)
Pectoral fin length (Lp)	40 (1.9%)
Body depth (H)	65 (3.1% TL)
Head length (C)	155 (7.3% TL)
Eye diameter (O)	12 (7.7% C)
Preorbital length (PO)	54 (34.8% C)
Interorbital length (Io)	18 (11.6%)
The number of pores in *linea lateralis*	202
The length of lower jaw	83

According to Morović (1973), the rarity of certain fish species could be evaluated from the records in scientific literature. Same author have pointed out that if the species is recorded less than five times, it should be treated as very rare. According to this suggestion, the serpent eel could be considered a relatively rare species in the Adriatic Sea. However, we should be careful when jumping to such conclusions, since we suppose that we must take into account tools (gears) for providing target species if wishing to evaluate their rarity. As far as the serpent eel is concerned, we should also take into account that this species lives buried with only its head exposed (Jardas, 1996). In view of its rarity we suppose that this is a case of inappropriate fishing gear use and burrowing of specimens in sandy and muddy bottom (all catches in the eastern Adriatic were done only by long-line). According to Tortonese (1970), this species is frequent in all Italian waters (including Adriatic); while Milišić (1994) noted that it is rare in the Adriatic Sea.

Fig. 2:** Ophisurus serpens **caught near the island of Sv. Fumija. (Photo: S. Matić-Skoko).
Sl. 2:** Ophisurus serpens**, ujeta v bližini otoka Sv. Fumija. (Foto: S. Matić-Skoko).

NOV PODATEK O POJAVLJANJU ZOBATE JEGULJE *OPHISURUS SERPENS* (LINNAEUS, 1758) (OPHICHTHIDAE) V JADRANSKEM MORJU

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POVZETEK

Dne 20. julija 2005 je bila nedaleč od otoka Sv. Fumija (v bližini otoka Čiovo, vzhodni srednji Jadran) ujeta zobata jegulja Ophisurus serpens. *To je vrsta, ki je v Jadranskem morju razmeroma redka. Predstavljene so glavne morfometrične podatke ujetega primerka, skupaj s pregledom novejših podatkov o tej vrsti iz Jadrana.*

Ključne besede: *Ophisurus serpens*, zapisi, Jadransko morje, morfometrija

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THE GULF OF GABÈS (CENTRAL MEDITERRANEAN): NURSERY AREA FOR THE SANDBAR SHARK, *CARCHARHINUS PLUMBEUS* (NARDO, 1827) (CHONDRICHTHYES: CARCHARHINIDAE)

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ABSTRACT

The investigations conducted between 2001 and 2004 in the Gulf of Gabès (southern Tunisian waters, central Mediterranean) enabled the authors to collect fourteen pregnant females of the sandbar shark, Carcharhinus plumbeus *(Nardo, 1827), containing 96 near-term embryos and 120 neonates exhibiting an unhealed umbilical scar on dorsal surface. Total mass* versus *total length relationship in neonates was positively correlated. Concomitantly, juveniles are found throughout the year. These observations suggest that the species found favourable environmental conditions to develop and reproduce in the area. Pregnant females give birth in the area from March to July. A sustainable sandbar shark population has probably been established in the Gulf of Gabès, which could also be considered an important Mediterranean nursery area for the species.*

Key words: Chondrichthyes, *Carcharhinus plumbeus*, nursery area, Gulf of Gabès, Tunisia, central Mediterranean

GOLFO DI GABÈS (MEDITERRANEO CENTRALE): AREA DI NURSERY PER SQUALO GRIGIO *CARCHARHINUS PLUMBEUS* (NARDO, 1827) (CHONDRICHTHYES: CARCHARHINIDAE)

SINTESI

Le ricerche condotte tra il 2001 e il 2004 nel Golfo di Gabès (acque della Tunisia meridionale, Mediterraneo centrale) hanno permesso agli autori di raccogliere quattordici femmine gravide di squalo grigio, Carcharhinus plumbeus *(Nardo, 1827), contenenti 96 embrioni quasi del tutto sviluppati e 120 neonati con visibile sul dorso la cicatrice dovuta al parto. Una correlazione positiva è stata riscontrata tra la massa totale e la lunghezza totale degli individui appena nati. Stadi giovanili della specie sono stati trovati nell'area durante l'intero anno. Tali osservazioni suggeriscono che lo squalo grigio ha trovato condizioni ambientali favorevoli allo sviluppo e alla riproduzione in quest'area. Le femmine gravide portano a termine la gestazione nel periodo da marzo a luglio. Una popolazione sostenibile di squalo grigio si è probabilmente stabilita nel Golfo di Gabès, che può venir considerata un'area di nursery importante per la specie nel Mediterraneo.*

Parole chiave: Chondrichthyes, *Carcharhinus plumbeus*, area di nursery, Golfo di Gabès, Tunisia, Mediterraneo centrale

INTRODUCTION

The Gulf of Gabès is located in southern Tunisian waters and extends for some 750 km (Figs. 1, 2), with its waters considered to present sub-tropical affinities according to Postel (1956). Both wide and shallow continental shelves are topographically regular. The bottom slightly declines towards the sea, and 60 m depth occurs at 110 km away from the shore. In the Gulf of Gabès, the highest tides of up to two metres have been recorded, as have in fact been reported from elsewhere in the Mediterranean (Ben Othman, 1973).

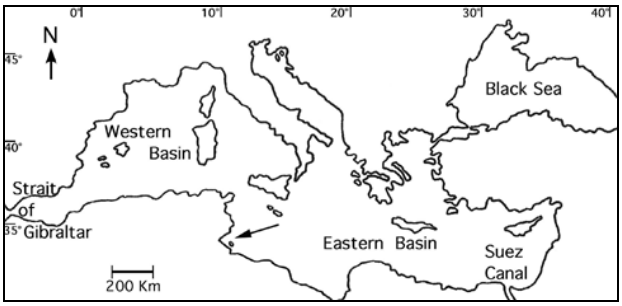

Fig. 1: Map of the Mediterranean Sea pointing at the Gulf of Gabès (black arrow).
Sl. 1: Zemljevid Sredozemskega morja z Gabeškim zalivom, označenim s črno puščico.

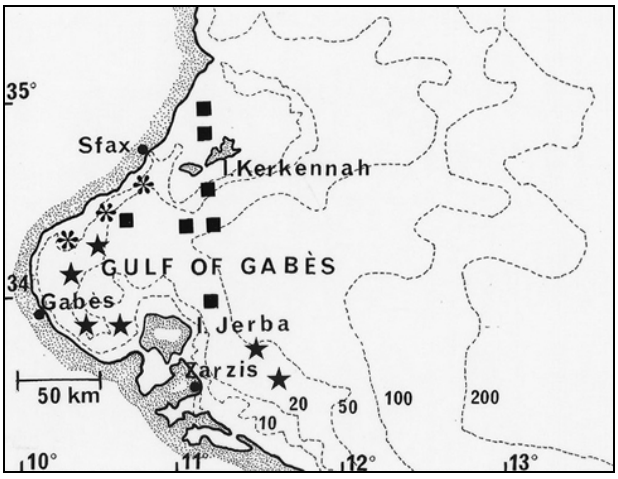

Fig. 2: Map of the Gulf of Gabès showing the capture sites of** Carcharhinus plumbeus **in the area. Legend: black stars – pregnant females, black asterisks – neonates, black squares - juveniles.
Sl. 2. Zemljevid Gabeškega zaliva z označenimi lokalitetami, kjer so bili ujeti sivi morski psi** Carcharhinus plumbeus**. Legenda: črne zvezde označujejo breje samice, črne zvezdice ravno skotene osebke, črni kvadrati pa mladiče.

The Gulf of Gabès is the most important Tunisian fishing area, comprising more than 50% of the local fishing fleet (Bradaï *et al.*, 1995). Throughout the year, commercial species are targeted, including sharks (Saïdi *et al.*, 2003), such as carcharhinids and smoothhounds of the genus *Mustelus*, especially between April and October.

Of the six carcharhinid species occurring in the Gulf of Gabès, *Carcharhinus plumbeus* is the first recorded and the most commonly landed throughout the year at the fishing sites of the area. Investigations conducted in the area during a five years period enabled us to collect several specimens and to find near-term females and small free-swimming specimens (Saïdi *et al.*, 2005). These new records provide additional data, which have improved our knowledge of the species in the area and confirmed previous papers in which the role of the Gulf of Gabès as the sharks' nursery area was suspected (Capapé, 1984; Bradaï *et al.*, 2002, 2004; Saïdi *et al.*, 2005).

MATERIAL AND METHODS

Data were collected from observations made at different fishing sites located along the Gulf of Gabès between 2001 and 2004. The specimens were caught by trawling, commercial gill-nets and longlines. Moreover, research surveys were conducted on board of the oceanographic trawler 'Hannibal' in May 2001, June 2002 and August 2003.

The specimens were measured to the nearest millimetre for total length (TL) following Bass *et al.* (1973) and weighed to the nearest kilogramme, when possible. The embryos removed from the uteri (see Fig. 3), and the smallest free-swimming specimens or neonates bearing an unhealed umbilical scar were measured to the nearest millimetre and weighed to the nearest gramme.

The onset of sexual maturity was determined in males from the condition and the length of claspers (CL). Bass *et al.* (1973), Stevens & Mc Loughlin (1991) and Watson & Smale (1998) have noted that the juveniles' claspers are short and flexible and that males are adult when claspers are rigid, elongated and calcified. The size of females at sexual maturity was determined from the condition of ovaries and the morphology of the reproductive tract following Natanson & Cailliet (1986), Capapé *et al.* (1990, 2002, 2005), Bridge *et al.* (1998) and Saïdi *et al.* (2005).

During the juvenile stage, the females ranging between 500 and 1640 mm TL had whitish ovaries, follicles of only microscopic size, membrane-like oviducts and inconspicuous oviducal glands. The collected juvenile females, ranging between 1640 and 1700 mm TL, had primarily white, translucent follicles, a well-differentiated genital duct and oviducal glands visible and slightly rounded (see Saïdi *et al.*, 2005).

A total of 712 females were captured in the Gulf of Gabès between January 2001 and May 2004. Of the 183 adult females observed, 18 only were non-eviscerated.

Tests for significance ($p < 0.05$) were performed by using ANOVA, Student *t*-test and the chi-square test. The linear regression was expressed in decimal logarithmic coordinates. Correlations were assessed by least-squares regression. In the relationship mass *vs.* total length, comparisons of curves were carried out by ANCOVA.

Length frequency data were collected from 120 neonates. Length frequency distributions were pooled by sex, at 10 mm intervals. The Kolmogorov-Smirnov two sample test was used to test significant difference in length frequencies.

RESULTS

Carcharhinus plumbeus is landed throughout the year at the fishing sites located in southern Tunisian waters (Bradaï *et al.*, 2002, 2004; Saïdi *et al.*, 2005). Of the 18 non-eviscerated adult females examined by us, 14 were pregnant females carrying near-term embryos (Tab. 1).

Ninety-six near-term embryos, 36 males and 60 females were collected (Tab. 1). The females TL ranged between 440 and 605 mm TL (mean: 530.8 mm ± 36.1), with mass between 479 and 1458 g (mean: 919.2 g ± 270.5). The males TL ranged between 430 and 590 mm (mean 525.2 mm ± 42.0), with mass between 391 and 1371 g (mean: 879.6 g ± 236.2).

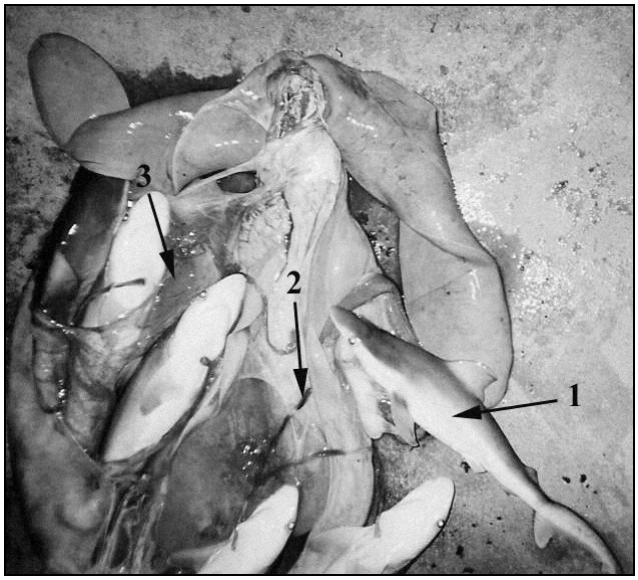

Fig. 3: Near-term embryos (1) removed from a pregnant female** C. plumbeus **showing umbilical cord (2) and uterine compartment (3).
Sl. 3: Že skoraj popolnoma razviti zarodki (1), odstranjeni iz breje samice** C. plumbeus **z dobro vidno popkovino (2) in maternično predelkom (3).

The relationship total mass *vs.* total length did not show significant differences between females and males. For females, the relationships are: log TM = 4.07 log TL – 8.15; r = 0.94; n = 60 and for males: log TM = 3.73 log TL – 7.21; r = 0.95; n = 32 (Fig. 4).

Tab. 1: Records of pregnant female** C. plumbeus **in the Gulf of Gabès with details on its uterine content.
Tab. 1: Podatki o breji samici** C. plumbeus **v Gabeškem zalivu, skupaj s podatki o vsebini samičine maternice.

Record	Month of catch	Female size (TL, mm)	Uterine content	Embryos number	Embryos size (TL, mm)	Embryos mass (g)
1	Mar	1910	Embryos	7	450-460	500-695
2	Mar	1970	Embryos	8	492-580	530-840
3	Mar	1990	Embryos	8	480-575	520-750
4	Apr	1795	Embryos	5	440-495	490-580
5	May	1720	Embryos	5	420-480	400-485
6	May	1775	Embryos	4	430-490	391-606
7	May	1895	Embryos	8	510-550	766-927
8	May	1790	Embryos	6	455-520	545-835
9	May	1980	Embryos	8	535-605	810-985
10	May	2000	Embryos	10	525-595	760-930
11	May	2100	Embryos	8	535-605	810-985
12	Jun	1770	Embryos	6	455-480	540-790
13	Jun	1800	Embryos	6	535-565	810-1050
14	Jul	1890	Embryos	7	570-625	990-1290
Total observed embryos				**96**	**-**	

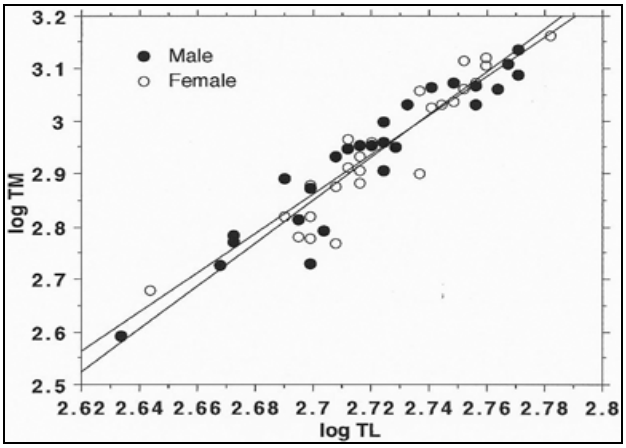

Fig. 4: Total Mass (TM)** vs. **Total Length (TL) relationship, expressed in logarithmic co-ordinates for male and female near-term embryos of** C. plumbeus**. TL was measured to the nearest mm and TM to the nearest gramme.
Sl. 4: Razmerje med celotno maso (TM) in celotno dolžino (TL), izraženo v logaritemskih koordinatah za že skoraj popolnoma razvite zarodke moškega in ženskega spola sivega morskega psa** C. plumbeus**. TL je bila izmerjena do najbližjega milimetra, TM do najbližjega grama.

Moreover, between August and September, 120 young free-swimming specimens, 62 females and 58 males, were observed; they exhibited an unhealed umbilical scar on the ventral surface, were neonates or at least born that year. The females TL ranged between 500 and 650 mm (mean: 590.44 mm ± 10.5), with mass between 851 and 1660 g (mean: 1264 g ± 115.7). The males TL ranged between 450 and 650 mm (mean: 600.0 mm ± 13.2), with mass between 400 and 1740 mm (mean: 1237.1 g ± 157.2).

In neonates as well as in embryos (cf. *supra*), the relationship total mass *versus* total length did not show significant differences between females and males. For females, the relationships are: log TM = 3.04 log TL - 5.33; r = 0.92; n = 62, and for males: log TM = 3.21 log TL - 5.90; r = 0.94; n = 58 (Fig. 5).

By contrast, the relationship total mass *versus* total length showed significant differences between near-term embryos (females + males) and neonates (females + males). For the former, the relationships are: log TM = 3.87 log TL - 7.59; r = 0.93; n = 96 and for the latter: log TM = 3.15 log TL - 5.57; r = 0.95; n = 120: F = 12.8; p = 0.005 (Fig. 6).

The overall length frequencies for neonates showed that practically similar sizes were reached by both sexes. The results of the Kolmogorov-Smirnov test indicate that the sexes were not sampled from populations with differing lengths distributions (p > 0.05); modal lengths were similar in both sexes (Fig. 7).

Near-term females were examined between March and July (see Table 1), but at the end of July this category of females disappeared from catches. These pregnant females were captured by demersal gill-nets (170 mm mesh size), at depths between 10 and 20 m in March and May, and at depths lesser than 10 meters from June to July, at sandy-muddy bottoms. These females were caught by special gill-nets, used only to capture sharks and locally known under the vernacular name of 'kallabia' (from *kalb' bhar*, which means shark in Arabic).

Soon after, neonates were captured from July to October (Fig. 8a), and no monthly significant differences were observed for both sexes (Fig. 8b). These neonates are usually captured at depths between 10 and 50 m, especially at sandy bottoms.

Tab. 2: Monthly collection of juvenile** C. plumbeus**, observed in the sample.
Tab. 2: Mesečna zbirka mladičev sivega morskega psa** C. plumbeus**, opazovanih v vzorcu.

Sex	Size (mm)	Months												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Males	700-900	2	3	13	23	30	19	14	12	2	25	9	5	157
	900-1100	4	2	3	7	3	20	22	23	3	5	3	5	100
	1100-1300	0	0	1	1	0	16	10	4	2	1	0	0	35
	1300-1500	0	0	0	2	10	7	0	3	0	1	0	0	23
	Total	6	5	17	33	43	62	46	42	7	32	12	10	315
Females	700-900	3	2	20	36	44	35	24	12	1	31	13	8	229
	900-1100	1	3	0	1	9	23	30	33	2	5	5	5	117
	1100-1300	1	0	0	3	2	12	10	18	0	1	1	0	48
	1300-1400	0	0	0	2	5	3	3	8	0	1	0	0	22
	1500-1700	0	0	0	4	14	6	0	1	3	0	1	0	29
	Total	5	5	20	46	74	79	67	72	6	38	20	13	445
General total		**11**	**10**	**37**	**79**	**117**	**141**	**113**	**114**	**13**	**70**	**32**	**23**	**760**

Furthermore, as juveniles are caught throughout the year, catches are significantly higher from May to September due to fact that sharks are targeted during this period of the year (Tab. 2).

DISCUSSION

Since the first record of *C. plumbeus* in the Gulf of Gabès, reported by Pietschmann (1906), a literature review shows, to date, a permanent occurrence of the species in the Gulf of Gabès (Postel, 1952, 1956, 1958; Quignard & Capapé, 1971; Capapé, 1974, 1984; Bradaï *et al.*, 2002, 2004; Saïdi *et al.*, 2005).

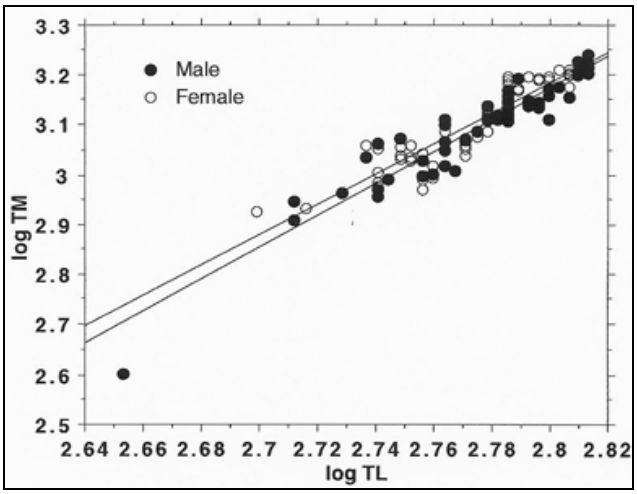

Fig. 5: Total Mass (TM)** vs. **Total Length (TL) relationship, expressed in logarithmic co-ordinates for male and female neonates of** C. plumbeus**. TL was measured to the nearest mm and TM to the nearest gramme.
Sl. 5: Razmerje med celotno maso (TM) in celotno dolžino (TL), izraženo v logaritemskih koordinatah za ravno skotene osebke moškega in ženskega spola sivega morskega psa** C. plumbeus**. TL je bila izmerjena do najbližjega milimetra, TM do najbližjega grama.

Moreover, Capapé (1989) showed that despite the competition pressure between carcharhinids in the Gulf of Gabès (see above Capapé *et al.*, 2003b, 2004), *C. plumbeus* is abundantly and commonly landed at local fishing sites (Saïdi *et al.*, 2003, 2005). These observations suggested that a sandbar shark population was definitively established in the Gulf of Gabès, and consequently, the occurrence of nurseries in the area. This occurrence has previously been suspected in preliminary data provided by Capapé (1974, 1984) who reported captures of both pregnant females and neonates *C. plumbeus* in southern Tunisian waters.

The results presented in this article showed a relative abundance of near-term females at depths between 10 and 20 m, lower than those usually reported for capture of large specimens (Quignard & Capapé, 1971). In these shallow waters, known to be energetically rich and the object of intensive fishery activities all year round (Bradaï *et al.*, 1995; Bradaï, 2000), neonates were concomitantly captured. So, pregnant females could obviously find sufficient resources to nourish embryos throughout gestation, which is also the case as far as neonates growing rapidly during the first weeks of their lives are concerned.

However, growth of embryos during gestation is significantly higher than in neonates (see Fig. 8). These observations firstly confirm the mother's role during embryonic development in viviparous placental species (Capapé *et al.*, 2003a, 2004; Saïdi *et al.*, 2005) and secondly that neonates were not probably experimented feeders during the first period of their extra-uterine lives, at least (Capapé *et al.*, 2003a).

Captures of near-term females occurred between March and July, and after this period no near-term females were captured in the area. These disappearance is immediately followed by captures of neonates between July and October. This suggests that *post-partum* females migrated off-shore towards deeper areas. Similar patterns were reported by Springer (1960, 1967) for *C. plumbeus*, from the Atlantic coast of the United States of America and the Gulf of Mexico.

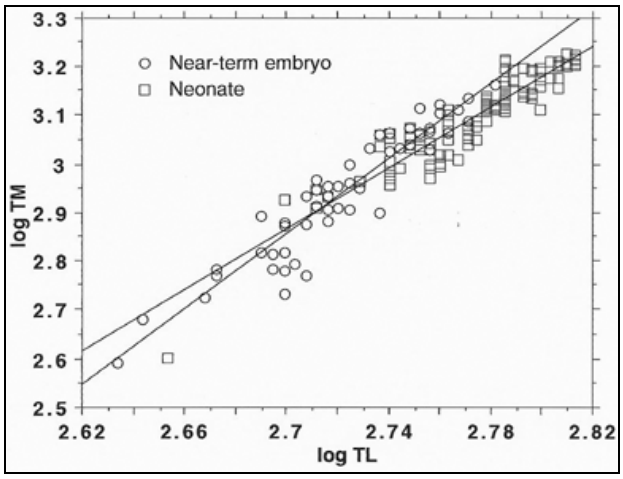

Fig. 6: Total Mass (TM)** vs. **Total Length (TL) relationship, expressed in logarithmic co-ordinates for near-term embryos and for neonates** C. plumbeus**. TL was measured to the nearest mm and TM to the nearest gramme.
Sl. 6: Razmerje med celotno maso (TM) in celotno dolžino (TL), izraženo v logaritemskih koordinatah za skoraj popolnoma razvite zarodke in ravno skotene osebke sivega morskega psa** C. plumbeus**. TL je bila izmerjena do najbližjega milimetra, TM do najbližjega grama.

Nevertheless, a competition pressure with sympatric carcharhinid species and predation by larger sharks have been considerably reduced (Capapé, 1989; Capapé *et al.*, 2003b; Bradaï *et al.*, 2002, 2004), although they could not be totally excluded (see Heupel & Hueter, 2002; Castro, 1993).

Moreover, the permanent and historical occurrence of juveniles in the Gulf of Gabès (see Table 1) showed that *C. plumbeus* reproduced and developed in the area (see Saïdi *et al.*, 2005). This suggests that the Gulf of Gabès could be a nursery area for the sandbar shark.

In the northern Mediterranean (Adriatic Sea), juvenile specimens have been collected by Lipej *et al.* (2000), whereas Costantini & Affronte (2003) recorded neonates bearing umbilical scars and ranging between 465 and 688 cm TL. Moreover, a pregnant female, 2 m TL and 70 kg in mass, was recorded in the same area by Travaglini (1982, in Costantini & Affronte, 2003). On the basis of these findings, Costantini & Affronte (2003) suggested 'that the northern Adriatic Sea is an important nursery ground for *C. plumbeus*'. In 2003, when de Sabata *et al.* (2003) observed juveniles *C. plumbeus* and pregnant females during their diving off Turkey, a female was filmed giving birth. De Sabata *et al.* (2003) suggested that bay in Turkey was the single known nursery site to date as far as the Mediterranean Sea is concerned. However, the mere presence of neonates or near-term pregnant females could not be considered sufficient parameters in order to delineate this area a shark nursery (see Castro, 1993).

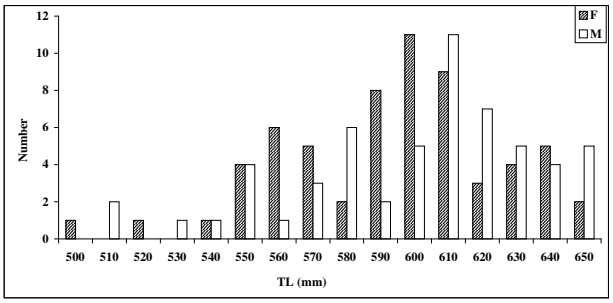

Fig. 7: Length distribution of male and female neonates of** C. plumbeus**, examined during the present study.
Sl. 7: Dolžine osebkov obeh spolov ravno skotenih mladičev sivih morskih psov** C. plumbeus**, preučevanih med pričujočo raziskavo.

Ben-Tuvia (1966) and Garrick (1982) considered the Red Sea a source for some Mediterranean carcharhinids, such as *C. brevipinna* and *C. limbatus*. However, they did not comment on the occurrence of *C. plumbeus*. The sandbar shark is relatively abundant in the Red Sea (Gohar & Mazhar, 1964; Baranes & Wendling, 1981), and as pregnant females were found in the area (Baranes & Wendling, 1981), migrations through the Suez Canal remain doubtful. Furthermore, Hemida *et al.* (2002) and Hemida & Capapé (2003) reported on recent occurrence of carcharhinid species off the Algerian coast, originating from the eastern tropical Atlantic and entering the Mediterranean Sea through the Strait of Gibraltar, and among them sandbar sharks were mainly recorded. An Atlantic source for *C. plumbeus* requires further confirmation, but as these records were recorded only recently, they cannot explain the early abundance of *C. plumbeus* in the Gulf of Gabès. By contrast, a Tunisian source for sandbar sharks for other Mediterranean areas, such as the Adriatic Sea, remains a suitable hypothesis.

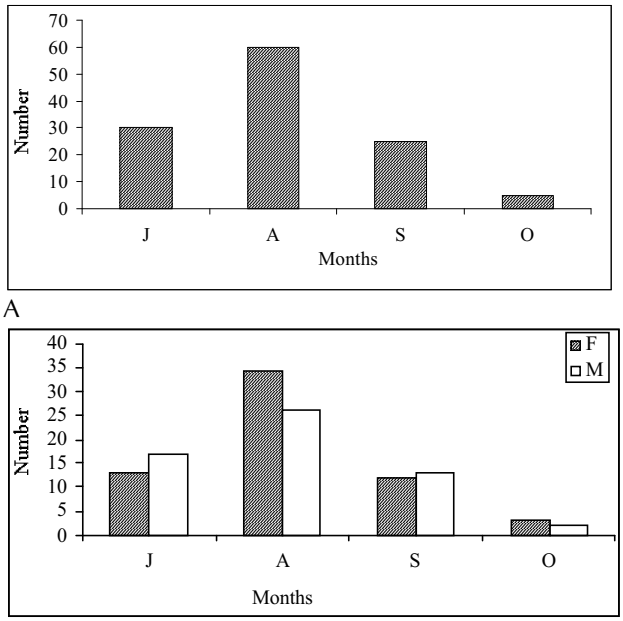

Fig. 8: (A) Monthly distribution of neonate** C. plumbeus**, examined during the present study between July and October. (B) Monthly distribution of** C. plumbeus **male and female neonates, examined during the present study between July and October.
Sl. 8: (A) Mesečna razporeditev ravno skotenih osebkov sivih morskih psov** C. plumbeus**, preučevanih med julijem in oktobrom. (B) Mesečna razporeditev ravno skotenih osebkov moškega in ženskega spola sivih morskih psov** C. plumbeus**, preučevanih med julijem in oktobrom.

GABEŠKI ZALIV (SREDNJE SREDOZEMLJE): RAZMNOŽEVALNO OKOLJE SIVEGA MORSKEGA PSA *CARCHARHINUS PLUMBEUS* (NARDO, 1827) (CHONDRICHTHYES: CARCHARHINIDAE)

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POVZETEK

Raziskave, opravljene med letoma 2001 in 2004 v Gabeškem zalivu (Tunizija, srednje Sredozemlje), so avtorjem omogočile, da so preučili štirinajst brejih samic sivega morskega psa Carcharhinus plumbeus *(Nardo, 1827) s 96 že skoraj popolnoma razvitimi zarodki in 120 ravno skotenimi osebki, s poporodno brazgotino na hrbtu. Razmerje med celotno maso in celotno dolžino pri skotenih osebkih je bilo premosorazmerno. Mladiče sivega morskega psa je v celotnem območju mogoče najti ob vsakem letnem času. Ta opažanja dajejo misliti, da je vrsta našla ustrezne okoljske razmere za razvoj in razmnoževanje v teh vodah. Breje samice tu rojevajo med marcem in julijem. Gabeški zaliv je območje, v katerem se je najbrž razvila trajnostna populacija sivega morskega psa, in bi utegnil biti tudi pomembno sredozemsko razmnoževalno okolje za to vrsto.*

Ključne besede: Chondrichthyes, *Carcharhinus plumbeus*, razmnoževalno okolje, Gabeški zaliv, tunizijska obala, srednje Sredozemlje

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ON THE OCCURRENCE OF THE PORBEAGLE, *LAMNA NASUS* (BONNATERRE, 1788) (CHONDRICHTHYES: LAMNIDAE), OFF ITALIAN COASTS (NORTHERN AND CENTRAL MEDITERRANEAN SEA): A HISTORICAL SURVEY

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ABSTRACT

In Italian Seas, a total of 33 Lamna nasus *were recorded, ranging in size between 86.7 and about 250 cm; 10 were females, 5 males and 18 of unknown sex. Of the 33 observed specimens, 14 were considered as possibly mature, corresponding to 42.4%. In the Adriatic and Ligurian Seas, four new-born specimens were recorded, ranging in size between 86.7 and 91 cm. It seems that* L. nasus *does not reproduce in Italian seas, although its reproductive area may exist in some other part of the Mediterranean.* L. nasus *was most often recorded during the summer, but seems to be present in the study area throughout the year.*

Key words: Chondrichthyes, Lamnidae, porbeagle, *Lamna nasus*, Italian seas, Mediterranean Sea

PRESENZA STORICA E CONTEMPORANEA DELLO SMERIGLIO, *LAMNA NASUS* (BONNATERRE, 1788) (CHONDRICHTHYES: LAMNIDAE), IN ACQUE ITALIANE (MARE MEDITERRANEO)

SINTESI

Un totale di 33 esemplari di Lamna nasus *viene segnalato nei mari d'Italia. Le dimensioni degli esemplari sono comprese tra 86,7 e circa 250 cm; 10 erano femmine, 5 maschi e 18 di sesso ignoto. Abbiamo stimato 14 dei 33 esemplari come verosimilmente maturi, corrispondenti al 42,4%. Quattro neonati sono stati registrati nei Mari Adriatico e Ligure, di dimensioni comprese tra 86,7 e 91 cm.* L. nasus *sembrerebbe non riprodursi nelle acque italiane, ma un'area riproduttiva potrebbe esistere all'interno del bacino Mediterraneo.* L. nasus *è stato registrato più frequentemente durante l'estate, ma sembra essere presente nell'area di studio durante tutto l'anno.*

Parole chiave: Condritti, Lamnidae, smeriglio, *Lamna nasus*, mari italiani, Mare Mediterraneo

INTRODUCTION

The porbeagle *Lamna nasus* (Bonnaterre, 1788) is a member of the Lamnidae Müller & Henle, 1838 family. It can be easily identified by its spindle-shaped body, strongly conical snout, lunate caudal fin, strong primary caudal keels and small secondary keels, moderately large bladelike teeth with a pair of lateral cusplets, a conspicuous white rear tip of first dorsal fin (Castro, 1983; Compagno, 1984). Its speed and power can be explained by a complex blood vessel heat-exchanging arrangement: in fact, we could consider this condition as warm-bloodedness or endothermy, well known also in other mackerel sharks (Carey *et al.*, 1985). It feeds on bony fishes, sharks, squids and crustaceans (Joyce *et al.*, 2002). Its longevity estimate is 46 years (Natanson *et al.*, 2002).

The porbeagle is an important object of commercial fisheries all around the world for its high-quality meat, mainly caught on pelagic longlines, and also highly considered for sport-fishery. Intensive fishery greatly reduced the population of porbeagles in the North Atlantic Ocean and the Mediterranean Sea (Castro, 1983; Compagno, 1984; Moreno, 1995; Vannuccini, 1999; Watts, 2001).

The porbeagle is a pelagic, epipelagic, or littoral shark that is usually more common on continental shelves, but is also found far from land in ocean basins (Scott & Scott, 1988; Compagno 2001). It ranges in depth from the surface to at least 700 m (Compagno, 2001). It prefers waters colder than 18° C (Aasen, 1963). It is widely distributed in the cold temperate waters of the North Atlantic, South Atlantic, South Indian and South Pacific Oceans. In the Mediterranean, it is indicated as rare or very rare in all waters (Tortonese, 1938; Capapé, 1989; Buencuerpo *et al.*, 1998; Barrull *et al.*, 1999; Kabasakal, 2003; Kabasakal & Kabasakal, 2004; Lipej *et al.*, 2004). Therefore, we consider it particularly interesting to provide a survey on the occurrence of porbeagles off Italian coasts based on both historical and recent data.

MATERIAL AND METHODS

The search for data on porbeagles from the Italian seas was effectuated by examination of the captured sharks, location and study of specimens preserved in natural history museums, collaboration with commercial fishermen, sport fishermen, scuba divers and bibliographical research. This program is an initiative lead by the Italian Ichthyological Society (Società Ittiologica Italiana).

For every case, whenever possible, the following data were collected: date and location of the record, total length (TOT) or fork length (FOR) in cm (following Compagno, 1984), weight in kg, sex of the specimen, type of record (capture or sighting), distance from the coast, information about specimens preserved in museums and catalogue number (cat. no.) in the collections, as well as any additional details. Detailed morphometric measurements were made by A. De Maddalena of a 163 cm male porbeagle caught off Cesenatico (Italy), Adriatic Sea, on 4 July 2001, following the procedure of Compagno (1984). The fork length – total length relationship presented by Kohler *et al.* (1996), FL = (0.8971) TL + 1.7939, was used to calculate the total length of a porbeagle caught off Stromboli.

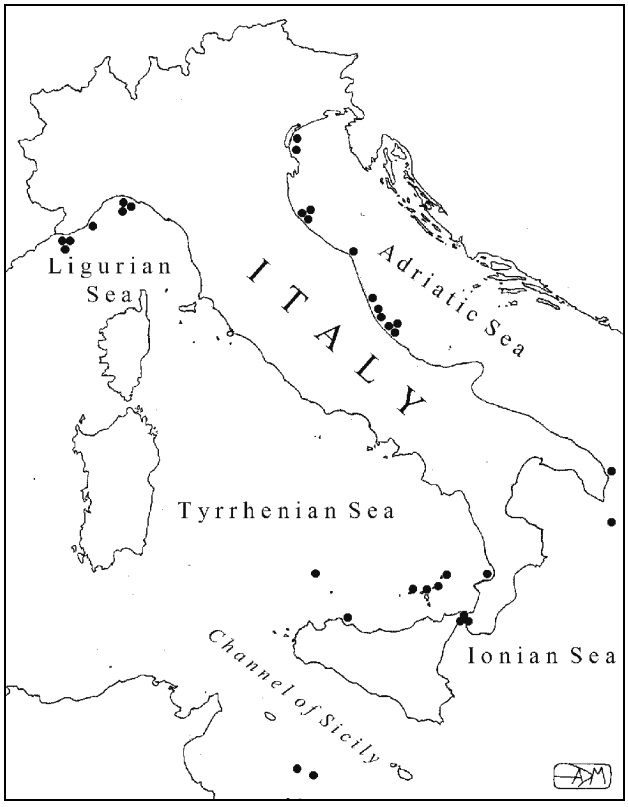

Fig. 1: Area of the Mediterranean Sea showing the locations of porbeagle captures and sightings presented in this work. (Drawing: A. De Maddalena)
Sl. 1: Območje Sredozemskega morja z lokalitetami, v katerih so bili ujeti in opaženi atlantski skušolovci, predstavljeni v tem članku. (Risba: A. De Maddalena)

RESULTS

To date, 33 *L. nasus* have been recorded off Italian coasts (Fig. 1). Of these, 7 are referred to the Ligurian Sea, 10 to the Southern Tyrrhenian Sea and the Messina Strait, 2 to the Sicilian Channel, 1 to the Ionian Sea and 13 to the Western Adriatic Sea.

In addition to the records described above, for the sake of completeness, it is of some interest to report that in other museums there are three additional specimens

Tab 1: Records of the porbeagle** Lamna nasus **(Bonnaterre, 1788) from Italian seas.
Tab. 1: Podatki o atlantskem skušolovcu** Lamna nasus **(Bonnaterre, 1788) iz italijanskih morij.

Date	Location	Sex	TOT (cm)	Weight (kg)	Notes	Source
1871	Palermo	-	-	-	Capture	Doderlein (1881)
Nov 1880	Alassio	-	-	-	Capture	Tortonese & Trotti (1949)
6 May 1913	Genova Boccadasse	F	200	-	Capture. Preserved taxidermied in the Museum of Natural History "G. Doria" of Genoa (cat. no. MSNG 1662).	Ariola (1913), Tortonese (1956), G. Doria *(pers. comm.)*
1958	Camogli	-	236	120	Caught in tuna-trap	Boero & Carli (1979)
7 Jul 1959	Pizzo Calabro	-	138	25	Capture	Genovese (1960)
summer 1987	Torre Faro	-	ca. 180	-	Caught with harpoon	A. Arena *(pers. comm.)*
Aug 1992	Otranto	-	ca. 250	-	Capture. Possibly the same specimen was encountered by scuba diver Andrea Del Coco a week earlier between Otranto and Porto Badisco.	A. Del Coco (*pers. comm.*)
1994	Albarella	-	-	240	Caught by sport-fishermen	R. Basanisi *(pers. comm.)*
summer 1995	Ganzirri	-	ca. 200	-	Caught with harpoon, 300 m offshore	M. Mancuso *(pers. comm.)*
31 Jul 1995	Pieve Ligure	-	-	-	Caught 6 NM offshore. Preserved in liquid in the Museum of Natural History "G. Doria" of Genoa (cat. no. MSNG 48692).	G. Doria *(pers. comm.)*
summer 1998	Lampedusa	-	ca. 200	-	Caught with surrounding net	P. Billeci *(pers. comm.)*
18 Aug 1998	Sanremo	F	87.1	-	Capture. Preserved in liquid in the Museum of Natural History "G. Doria" of Genoa (cat. no. MSNG 50789).	Orsi Relini & Garibaldi (2002), G. Doria *(pers. comm.)*
18 May 1999	Salina, Eolie Islands	F	175 (FOR)	-	Caught with tuna longline	Examined by A. C.
10 Sep 1999	Sanremo	F	86.7	-	Capture. Preserved in liquid in the Museum of Natural History "G. Doria" of Genoa (cat. no. MSNG 50785).	Orsi Relini & Garibaldi, (2002), G. Doria *(pers. comm.)*
Feb 2000	Eastern Ionian Sea	-	ca. 200	-	Caught with tuna longline	V. Testa *(pers. comm.)*
9 Feb 2000	Giulianova	-	163	-	Caught with tuna longline	A. Celona *(pers. comm.)*
summer 2000	Ancona	M	152	-	Caught with longline. Preserved in liquid in the Marine Biology Laboratory of Fano.	G. Mattioli *(pers. comm.)*
summer 2000	Pescara	-	ca. 200	-	Caught by sport-fishermen	Cugini & De Maddalena (2003)
21 Jul 2000	Capo San Raineri	F	185 (FOR)	-	Caught with harpoon	Examined by A. C.
31 Jul 2000	Sanremo	F	89.3	-	Capture. Preserved in liquid in the Museum of Natural History "G. Doria" of Genoa (cat. no. MSNG 50784).	Orsi Relini & Garibaldi (2002), G. Doria *(pers. comm.)*
May 2001	Southern Tyrrhenian Sea	-	ca. 180	-	Caught with tuna floating gillnet	A. Sanfilippo *(pers. comm.)*
8 May 2001	Pescara	M	ca. 150	35	Capture	Cugini & De Maddalena (2003)
12 Jun 2001	Panarea, Eolie Islands	-	ca. 200	-	Caught with surrounding net, 25 NM off Panarea	G. Galano *(pers. comm.)*
4 Jul 2001	Cesenatico	M	163	-	Brought to the fish market in Milan	Examined by A. D.
4 Jul 2001	Cesenatico	F	ca. 160	-	Brought to the fish market in Milan	L. Piscitelli *(pers. comm.)*
4 Jul 2001	Cesenatico	F	ca. 160	-	Brought to the fish market in Milan	L. Piscitelli *(pers. comm.)*
15 Jul 2001	S. Benedetto del Tronto	F	91	6.5	Caught by sport-fisherman. Stomach contained sardines, *Sardina pilchardus*. Preserved in the Museo Ittico Augusto Capriotti in San Benedetto del Tronto (cat. no. 1850).	Marconi & De Maddalena (2001)
Dec 2001	Pescara	F	ca. 250	-	Capture. Filmed.	Cugini & De Maddalena (2003)
Feb-Mar 2002	Giulianova	-	180	-	Caught by professional fisherman	Cugini & De Maddalena (2003)
10 Jun 2002	Filicudi, Eolie Islands	M	187 (FOR)	-	Caught with floating gillnet	Examined by A. C.
15 Apr 2003	Stromboli, Eolie Islands	M	206 (FOR)	-	Caught with tuna longline	Examined by A. C.
Feb 2004	Venezia	-	ca. 150	-	Capture	G. Cugini *(pers. comm.)*
26 Sep 2004	Lampione	-	ca. 200	-	Sighting	Sighted by A. C.

Fig. 2: A 163 cm male porbeagle** Lamna nasus **(Bonnaterre, 1788) caught off Cesenatico (Italy), Adriatic Sea, on 4 July 2001. (Photo: A. De Maddalena)
Sl. 2: 163 cm dolgi samec atlantskega skušolovca** Lamna nasus **(Bonnaterre, 1788), ujet 4. julija 2001 nedaleč od Cesenatica v Jadranskem morju. (Foto: A. De Maddalena)

whose capture location is unknown, but for which it can be hypothesized that they may be from Italian waters. In the Museum of Natural History and the Territory of Calci there is a young taxidermied preserved specimen, possibly referable to the 19th century, in the Museum of Natural History "Fontego dei Turchi" of Venice there is a 112 cm taxidermied female (cat. no. 7841) (Mizzan, 1994), and in the Museum of Natural History of Trieste there is a set of jaws belonging to a specimen caught in the Adriatic Sea.

For each specimen, the following data are reported in Table 1: capture date, capture location, sex (M or F), total length (TOT or, where indicated, FOR) in cm, weight in kg, notes and data source. Morphometric measurements of a 163 cm male porbeagle caught off Cesenatico on 4 July 2001 (Fig. 2) are presented in Table 2.

DISCUSSION

The paucity of data collected from Italian seas confirms the rarity of *L. nasus* in the Mediterranean area. *L. nasus* was recorded most often during the summer *(e.g.* Fig. 3), but seems to be present in the study area throughout the year.

The porbeagle is a large species that can reach 360 cm in total length (Castro, 1983; Compagno, 1984). The lengths of the specimens fell within the ranges previously described for this species. The recorded lengths of the specimens ranged from 86.7 to about 250 cm (*e.g.* Fig. 4). In December 2001, a large female was landed in the Pescara harbour, where it had been transported following its capture in adjacent waters. The total length of the specimen was not accurately measured, but it was subsequently estimated at about 250 cm (Cugini & De Maddalena, 2003). In late August 1992, an approx. 250 cm porbeagle was caught off Otranto; possibly the same specimen was encountered a week earlier by scuba diver Andrea Del Coco at 28 m depth, between Otranto and Porto Badisco (A. Del Coco, *pers. comm.).* Other large porbeagles recorded are a 236 cm specimen caught off Camogli in 1958 (Boero & Carli, 1979) and a 206 cm FOR male caught off Stromboli on 15 April 2003. From the fork length - total length relationship presented by Kohler *et al.* (1996), we calculated the total length of the Stromboli specimen to be 227.63 cm.

Of the 33 specimens, 10 were females, 5 males and 18 of unknown sex. Porbeagle's mode of reproduction is aplacental viviparity and embryos are nourished by oophagy; *L. nasus* may take 5 or more years to reach maturity: in the Northern Hemisphere, males mature at about 150-200 cm total length, females at about 200-229 cm (Francis & Stevens, 2000; Barrull & Mate, 2002). In our study, gonads were not examined, and we estimated the reproductive state on the basis of the specimens' size. In total we estimated 14 of the 33 specimens as possibly mature, corresponding to 42.4%. The gestation period is 8–9 months (Francis & Stevens, 2000), and in the North Atlantic birth occurs in spring and summer (Castro, 1983; Francis & Stevens, 2000); litter sizes are 2-6, and size at birth is 68-89 cm total length (Francis & Stevens, 2000; Mollet, 2001; Jensen *et al.,* 2002). In our study, four new-born specimens, ranging from 86.7 to 91 cm, were recorded – one from the Adriatic Sea and three from the Ligurian Sea (Marconi & De Maddalena, 2001; Orsi Relini & Garibaldi, 2002; G. Doria, *pers. comm.*). No pregnant females were recorded. We

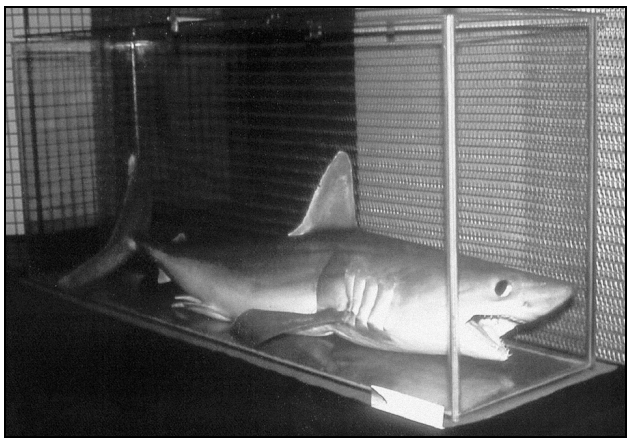

Fig. 3: A 152 cm male porbeagle** L. nasus **caught off Ancona (Italy), Adriatic Sea, in the summer of 2000, and preserved in the Marine Biology Laboratory of Fano. (Photo: M. Zuffa)
Sl. 3: 152 cm dolgi samec atlantskega skušolovca** L. nasus**, ujet poleti 2000 nedaleč od Ancone v Jadranskem morju in shranjen v Morskem biološkem laboratoriju v Fanu. (Foto: M. Zuffa)

Tab. 2: Measurements of a 163 cm male porbeagle *Lamna nasus* ***(Bonnaterre, 1788) caught off Cesenatico (Italy), Adriatic Sea, on 4 July 2001 (following terminology and parameters of Compagno, 1984). All measurements are given in centimetres.***
Tab. 2: Dimenzije 163 cm dolgega samca atlantskega skušolovca *Lamna nasus* ***(Bonnaterre, 1788), ujetega 4. julija 2001 v bližini Cesenatica (Italija), Jadransko morje (po terminologiji in parametrih Compagna, 1984). Vse dimenzije so v cm.***

Abbreviation	Measurement	cm	% TOT
TOT	total length (caudal fin in depressed position)	163	100.0
FOR	fork length	139	85.3
PRC	precaudal length	124.5	76.4
PD2	pre-second dorsal length	110	67.5
PD1	pre-first dorsal length	53	32.5
PG1	prebranchial length	33.5	20.6
POB	preorbital length	11.4	7.0
PP1	prepectoral length	41.5	25.5
PP2	prepelvic length	85	52.2
PAL	preanal length	111.5	68.4
PRN	prenarial length	8	4.9
POR	preoral length	10	6.1
EYL	eye length	3.1	1.8
EYH	eye height	2.6	1.6
GS1	first gill slit height	12	7.4
P1A	pectoral anterior margin	28.8	17.7
P1B	pectoral base	12	7.4
P1P	pectoral posterior margin	25	15.3
CDM	dorsal caudal margin	38	23.3
CPV	preventral caudal margin	25	15.3
CPL	lower post ventral caudal margin	18.5	11.4
D1A	first dorsal anterior margin	21	12.9
D1B	first dorsal base	14	8.6
D1H	first dorsal height	18.5	11.4
D1I	first dorsal inner margin	6.5	4.0
D2A	second dorsal anterior margin	5	3.1
D2B	second dorsal base	2.5	1.5
D2H	second dorsal height	3	1.8
D2I	second dorsal inner margin	5	3.1
D2P	second dorsal posterior margin	5	3.1
ANA	anal anterior margin	5	3.1
ANB	anal base	3	1.8
ANH	anal height	3.5	2.2
ANI	anal inner margin	5	3.1
ANP	anal posterior margin	4.5	2.8
MOL	mouth length	7.5	4.6
MOW	mouth width	11.5	7.1
NOW	nostril width	1.5	0.9

therefore presume that *L. nasus* does not reproduce in Italian seas, but given the presence of new-born specimens we cannot exclude that a reproductive area may exist in some other part of the Mediterranean Sea.

Porbeagles appear to be inoffensive animals. These sharks very rarely approach divers closely. We are unaware of any aggressive, provoked or unprovoked incidents involving humans in these waters.

Apparently, porbeagles are rarely caught by professional fishermen operating in the study area. The fishing gear used is pelagic longlines, floating gillnets, surrounding nets, tuna-traps and harpoon. Most porbeagles

were taken as bycatch, primarily with the same pelagic longlines used to fish tuna and swordfish. These sharks were retained and sold for human consumption. Due to its large size and high quality flesh, porbeagle is considered an important source of shark meat in Italy. In domestic markets, porbeagle meat is marketed fresh or frozen for human consumption. It can often be found in the markets, but mainly imported from North-eastern Atlantic Countries and Japan (De Maddalena & Piscitelli, 2001). In Italy, the meat of many sharks is marketed under incorrect names and *L. nasus* is usually sold as "palombo" (smooth-hound *Mustelus* sp.).

There are no regulations or control over the porbeagle fishery in Italy. The absence of any other details on the porbeagle fishery in the area does not allow an assessment of the status of their stocks in these waters, however, according to local fishermen and traders, these sharks have greatly declined. Effective management of fisheries is needed in order to avoid a rapid decline in the near future. These management decisions are based on research on the biology, ecology, distribution, abundance and exploitation of the species. As the sharks constitute a significant by-catch of commercial fishing vessels, it is also necessary to improve management of fisheries for the effective conservation of shark populations (Vannuccini, 1999; Watts, 2001).

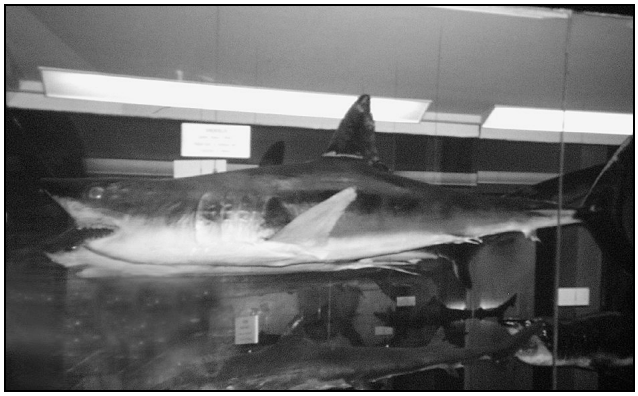

Fig. 4: A 200 cm female porbeagle** L. nasus **caught off Genova Boccadasse (Italy), Ligurian Sea, on 6 May 1913, and preserved in the Museum of Natural History "G. Doria" of Genoa with cat. no. MSNG 1662. (Photo: A. De Maddalena)
Sl. 4: 200 cm dolga samica atlantskega skušolovca** L. nasus, **ujeta 6. maja 1913 v Ligurskem morju (Italija) blizu Genove Boccadasse in shranjena v Prirodoslovnem muzeju "G. Doria" v Genovi pod katalοško številko MSNG 1662. (Foto. A. De Maddalena)

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O POJAVLJANJU ATLANTSKEGA SKUŠOLOVCA *LAMNA NASUS* (BONNATERRE, 1788) (CHONDRICHTHYES: LAMNIDAE) V ITALIJANSKIH OBALNIH VODAH (SEVERNO IN SREDNJE SREDOZEMSKO MORJE): ZGODOVINSKI PREGLED

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POVZETEK

V italijanskih morjih je bilo doslej zabeleženih 33 atlantskih skušolovcev Lamna nasus, dolgih med *86,7 in približno 250 cm; 10 je bilo samic, 5 samcev, 18 neznanega spola. Od 33 preučevanih osebkov jih je bilo 14 (42,4 %) najverjetneje spolno zrelih. V Jadranskem in Ligurskem morju so bili zabeleženi 4 novorojeni osebki, dolgi med 86,7 in 91 cm. Čeprav vse kaže, da se* L. nasus *ne razmnožuje v italijanskih morjih, pa utegne biti njegov razmnoževalni okoliš v kakem drugem delu Sredozemskega morja.* L. nasus *je bil najpogosteje ujet ali opažen v poletnih mesecih, vendar se v preučevanem območju najverjetneje pojavlja čez vse leto.*

Ključne besede: Chondrichthyes, Lamnidae, atlantski skušolovec, *Lamna nasus*, italijanska morja, Sredozemsko morje

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SHARK CHUMMING IN THE EASTERN ADRIATIC

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ABSTRACT

In the period July 18 – August 9, 2005, an expedition involving sharks was conducted in the central Eastern Adriatic. The expedition, organized by Richard Peirce, had an objective of obtaining new information on the population status of large pelagic predatory sharks in the Eastern Adriatic. It was conducted in the general area of the Jabuka Pit (Blitvenica area). For attracting sharks, chumming with various baits was conducted. On the basis of a 23 days at sea expedition, a total of 308.5 hours chumming were achieved. As result, there were only 9 confirmed records of blue shark, Prionace glauca*, which is a truly alarming result, indicating that shark populations in the central Adriatic are even more depleted than previously thought.*

Key words: sharks, chumming, Adriatic

PASTURAZIONE DI SQUALI IN ADRIATICO ORIENTALE

SINTESI

Nel periodo dal 18 luglio al 9 agosto del 2005 una spedizione incentrata sugli squali è stata condotta nell'Adriatico centro-orientale. La spedizione, organizzata da Richard Peirce, aveva lo scopo di raccogliere nuove informazioni sullo stato delle popolazioni di grandi predatori pelagici, quali gli squali, nell'Adriatico orientale. Lo studio si è svolto nell'area della cavità di Jabuka (area di Blitvenica). Per attirare gli squali con la pasturazione sono state adoperate varie esche. La spedizione è durata 23 giorni per un totale di 308,5 ore di pasturazione. Con tale tecnica sono stati avvistati solo 9 esemplari di verdesca, Prionace glauca*, risultato allarmante che indica che le popolazioni di squali nell'Adriatico centrale sono più impoverite di quanto si pensasse in precedenza.*

Parole chiave: squali, pasturazione, Adriatico

INTRODUCTION

The general objective of the expedition was to obtain new information on the status of large pelagic shark populations in the Eastern Adriatic. As large sharks, which are apex predators of the marine ecosystem and therefore considered as K – species, they are highly vulnerable to overfishing, both as target species or bycatch. In the Mediterranean, their decline has already been observed, which raised a concern for their status (Soldo, 2003). In the Adriatic, most of the large shark species (*e.g.* Lamnidae, Odontaspididae and even Carcharhinidae) have been considered as rare or very rare, although, previously, for example the great white, *Carcharodon carcharias*, and the shortfin mako, *Isurus oxyrinchus*, were believed to be constantly present in that area (Soldo & Jardas, 2002). Lately, even those species that were considered as most abundant, such as the blue shark, *Prionace glauca*, are showing considerable decline in catches and sighting. Although there are no direct shark fisheries in the Eastern Adriatic, except fishing of various small demersal chondrichthyans with gillnets (Cetinić & Soldo, 1999), many of the shark species were caught as bycatch by longlines, driftnets and other fishing gear used in tuna, small pelagic fish and sword fisheries. Hence, smaller shark species are also often bycatch of trawls. Comparison of catches of chondrichthyan fishes caught by research trawls in 1948–49 with the data from "MEDITS" program in 1997–98 shows considerable decline in abundance of 26 species of chondrichthyans, as well as major reductions of their distribution. For example, the thornback ray, *Raja clavata*, has gone from high abundance and widespread distribution throughout the Adriatic Sea to being restricted to a small area with low abundance (Soldo, 2002). Therefore, there is a general agreement that more investigations are necessary to know population status of all shark species, and especially the large species that are mainly cosmopolitan, migratory species, the status of which is therefore harder to assess.

MATERIAL AND METHODS

The expedition was conducted in the area of Jabuka Pit (Blitvenica area) (Fig. 1), which is probably the most important fishing area in the Adriatic. Hence, this is also the area of most intensive big game fishing, targeting bluefin tuna, *Thunnus thynnus*, albacore tuna, *Thunnus alalunga*, swordfish, *Xiphias gladius,* amberjack, *Seriola dumerili*, dorado, *Coryphaena hippurus* and sharks, mainly blue shark and thresher shark, *Alopias vulpinus*. Although reports from big game fishing indicated that best season for shark encountering is end of May – beginning of June that is also a season with bad weather conditions on the sea. Therefore, in order to maintain day-by-day chumming it was decided to conduct the expedition in period July 18 – August 9, 2005, with the calmest days at sea in the area. It was planned to have 400–425 hours of chumming at six different sites. Later on, the area of Kornati – Dugi otok was added, since the authors had received reports by several fishermen that this area is a possible pupping area for blue sharks.

Two boats were used: Baracuda, as main vessel, had six berths and 15 m in length and supported by the 8.5 m Lucia, with three berths.

The expedition used various chum techniques with chum stations sunk to various depths, including below the thermocline. Hooks were used hoping for captures and tagging. These were also deployed at various depths with various different baits. For chumming, sardines were the main material used. Two blue fin tuna were caught by boat skippers, and tuna blood, heads, tails and guts were also used as chum. Richard Peirce and Craig Ferreira each led a team of four volunteers and alternated working 24 hour shifts. Two pairs each worked 3 hour watches from 08.00 – 20.00 and then 2 hour watches through the night. During darkness, the area astern of the main boat was illuminated. Overall, there were 2 expedition leaders and 14 volunteer researchers.

In case a great white shark was to be encountered, a Pop off Archival Tag set for 90 days would have been deployed. Furthermore, tissue samples were to be taken from any white sharks, porbeagles, shortfin makos or threshers encountered and return tags were to be fitted to as many specimens as possible. The main vessel was equipped with shark steel cage in order to allow underwater recording in case a white shark was to be encountered.

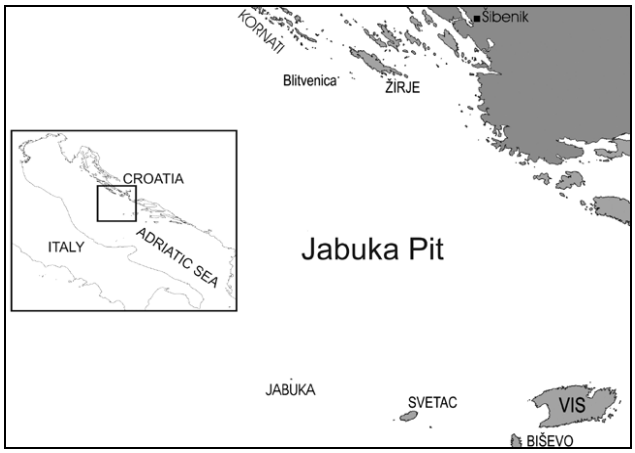

Fig. 1: Investigated area of the Jabuka Pit (Blitvenica area).
Sl. 1: Raziskovani predel kotline Jabuka (območje Blitvenice).

RESULTS AND DISCUSSION

Of the previously planned 400–425 hours of chumming, a total of 308.5 hours was achieved. Eight complete 24 hour periods were chummed with eleven further days of chumming activity between 3.5 and 23 hours.

Results of the chumming were as follows:

- nine (9) blue sharks (*Prionace glauca*) were caught and released or sighted round boats,
- several (at least 18) eagle rays, *Myliobatis aquila*, were seen,
- four (4) confirmed incidents (species unknown) of attacks on bait bags and chum stations were recorded (Tab. 1).

In addition to the expedition results, it is possible to add credible reports of a further seven (7) records of blue sharks, *P. glauca*, that were caught or seen and identified by other angling boats operating in near area.

Thus, the expedition's 308.5 hours chumming produced only nine records of blue sharks. If the 7 blue sharks identified by angling boats are added, the total number of observed blue sharks is 16 with the total chumming time increasing to something over 400 hours. Important data was also collected from the Dugi otok – Kornati area, which was considered as potential pupping area of blue shark. Nine hours and fifty minutes chumming was done in this area from two boats covering a drifted area of 3.5 NM. The only specimen identified was a 0.6 metre blue shark female pup that was tagged and released. Although the record of only one specimen is not a conclusive proof of a pupping ground, given that the only specimen encountered was a pup, the indication is that the reports considering this area as pupping ground of blue shark are probably correct, but need more thorough investigation for support of such presumption.

Overall result of this expedition is that out of 28 shark species inhabiting the Adriatic (Lipej *et al.,* 2004), there were only 16 confirmed records of only one species, the blue shark, in more than 400 hours of chumming at 7 different sites, which is a truly alarming result.

Regarding the great white shark, these results were probably expected, as Soldo & Jardas (2002) suggested that apparent lack of records of great white shark, since 1974, was related to the decline of tuna abundance in coastal waters of the Eastern Adriatic. Absence of great marine mammals in the Eastern Adriatic placed tunas as a mayor prey for the great white shark. Same authors also presumed that any future records of the great white shark in the Eastern Adriatic would probably be in the open Adriatic and related to tuna. A new record in the summer of 2003 confirmed such theory as a female shark was caught in tuna purse seine 15 NM southwest offshore the island of Jabuka (Soldo & Dulčić, 2005). Data on shortfin mako have shown even severer decline of this species in the Eastern Adriatic. This species was considered as very common in the Eastern Adriatic at the end of the 19th century, as 43 records were reported in that period. During the 20th century, only 5 new records were reported, and since 1972 there have been no more records of this species in the Eastern Adriatic (Soldo & Jardas, 2002). Although the same authors indicated that the shortfin mako probably still occurs in open waters of the Adriatic, where it can be, because of its size and shape, misidentified by fisherman as the blue shark, or some other shark species, this expedition has not found any evidence of presence of this species in the Eastern Adriatic area. Similar case was for porbeagle, *Lamna nasus,* which latest authors also considered as probably occurring in the Adriatic's open waters, but unfortunately no records of this species were obtain by this expedition, although there have been recent reports on capture of this species in same area.

However, regarding thresher shark, a common shark of the Eastern Adriatic, and blue shark, the most common species of large sharks in the Adriatic, as indicated by Soldo & Jardas (2002), these results clearly point out that their common species status is no longer valid, as their populations are probably more depleted than previously thought.

Results of this expedition have to be used as part of efforts to establish protection for some species and sustainable fisheries management plans for the Adriatic Sea. Therefore, it is of great importance to identify critical habitats, namely mating areas, spawning and nursery grounds of all shark species, especially large, in the Adriatic. Management programs should be developed in the way that would ensure precise fisheries statistics of catches and landings by species.

Furthermore, for large migratory species it is of essential importance that shark management programs should be developed in the entire Mediterranean, followed by local ones (Adriatic). These programs should respect the principles of sustainability, precautionary principle and conservation measures as defined in the FAO Code of Conduct for Responsible Fisheries and in the International Plan of Action for the Conservation and Management of Sharks.

Hopefully, such approach, which should be very fast, will ensure conservation of shark populations and biodiversity of marine ecosystem of the Adriatic, as well as in the Mediterranean Sea.

Tab. 1: Records of shark occurrences obtained by chumming in the period from July 18 to August 9, 2005, in the areas of Jabuka Pit and Kornati archipelago (eastern Adriatic).
Tab. 1: Zapisi o pojavljanju morskih psov na podlagi privabljanja z deli razkosanih rib v obdobju od 18. julija do 9. avgusta 2005 na območju kotline Jabuka in Kornatov (vzhodni Jadran).

Date	Location	Depth (m)	Chummed hrs.	Species	Comments
18 Jul	18 NM from shore, edge of Jabuka pit 43°N, 15°E	200	7	-	Bad weather forced to run for shelter
19 Jul	18 NM from shore, edge of Jabuka pit 43°N, 15°E	200	7	probable sharks	Chum station left at sea overnight. Evidence of attack. Deep chum station attacked at 2200 hours. Bag ripped open.
20 Jul	18 NM from shore, edge of Jabuka pit 43°N, 15°E	200	24	-	-
21 Jul	18 NM from shore, edge of Jabuka pit 43°N, 15°E	200	24	AM, tuna astern in chum slick.	The marine environment around the boats starting to change significantly with large numbers of various fish ever present.
21 Jul	18 NM from shore, edge of Jabuka pit 43°N, 15°E	200	24	PM, blue fin tuna strike, 120 kg fish	Just after tuna strike as the 20 m chum station was being retrieved the line was cut and we lost it. Tuna, or shark chasing tuna?
22 Jul	18 NM from shore, edge of Jabuka pit 43°N, 15°E	200	24	-	-
23 Jul	18 NM from shore, edge of Jabuka pit 43°N, 15°E	200	24	rays	Eagle rays regularly in chummed area.
24 Jul	18 NM from shore, edge of Jabuka pit 43°N, 15°E	200	24	rays	-
25 Jul	18 NM from shore, edge of Jabuka pit 43°N, 15°E	200	14	tuna breaking surface, rays.	We set 150 hooks on a bottom longline at 190 m in the chummed area. 3 small European congers – nothing else.
25 Jul	2 NM SW of Blitvenica lighthouse	200	8.25	blue shark	New location considerably larger numbers of bait fish immediately present. 2000 hours our shuttle boat fishing near our slick caught and released a 0.6 m juvenile blue shark.
26 Jul	Drifting SW Blitvenica approx 6 NM	200	17	blue shark, several small ray	0025 hrs a 1.5–2 m shark swam through the floodlit area astern of Baracuda
27 Jul	Drifting SW Blitvenica approx 6 NM	200	17	female blue shark 2.5 m	Specimen caught to tag, lip hooked on a monofilament leader, bit through and lost. Wrong leader fitted!
27 Jul	Location 8-10 NM SW Blitvenica	200	-	report of a 120 kg blue shark caught 2-3 NM SW Blitvenica	Location and size estimate as reported to us.

28 Jul	Drifting 10-12 NM SW Blitvenica	200	7	-	-
29 Jul	Drifting 4-5 NM SW Blitvenica	160	10	rays	-
30 Jul	Drifting 4-5 NM SW Blitvenica	140-160	24	blue shark 2205 hours	1.5-2 m specimen swimming in chummed area astern of Baracuda.
30 Jul	Drifting 4-5 NM SW Blitvenica	140-160	24	blue shark 2234 hours	Second specimen 2.5–3 m hooked to tag. Bit through line-lost.
31 Jul	Drifting 4-5 NM SW Blitvenica	140-160	24	blue shark 542 hours	Small shark 1–1.5 m swimming eastern of Baracuda.
31 Jul	Drifting 4-5 NM SW Blitvenica	140-160	24	2 x blue sharks caught and released by our shuttle boat, 1830–1900 hours. Sizes est. 2 and 2.5 m	1 NM north of our position. Sexes unknown.
1 Aug	Same general area, drifting	170	24	2 x blue sharks caught and released, untagged by Baracuda skipper	1 m and 1.5 m: one male and one female.
2 Aug	Same general area, drifting	170	12	-	-
2 Aug	2.5 NM south of Jabuka	150	3.5	-	Severe weather forced to stop chumming after only 3.5 h and run for shelter.
3 Aug	-	-	-	-	Due to storm warnings steamed back to mainland from Vis.
4-5 Aug	-	-	-	-	In port waiting for clear weather.
6 Aug	43°49.62′N, 15°12.47′E junction Dugi Otok and Kornati, drift chumming	90	3	-	We drift 3.1 NM. 10x blue sharks seen in this location yesterday – none today.
7 Aug	43°48.58′N, 15°11.46′E drift chumming working south of the day before position	90	9-50 min	female blue shark pup. 1015 hours, Baracuda	Two boats chumming separately drifted 3.5 NM. Shark of 0.6 m tagged and released.
9 Aug	43°41.77′N, 15°26.18′E	> 110	11	blue shark 1828 hours	2.5 m specimen swam round Lucia for 15–20 min.

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PREUČEVANJE POPULACIJ MORSKIH PSOV, PRIVABLJENIH Z DELI RIB, V VZHODNEM JADRANU

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POVZETEK

Glavni namen ekspedicije, ki jo je med 18. julijem in 9. avgustom 2005 v srednjem vzhodnem Jadranu vodil Richard Peirce, je bil dobiti kar največ novih informacij o pelagičnih plenilskih morskih psih v tem delu Jadrana. Raziskave so potekale v širšem predelu kotline Jabuka (območje Blitvenice). Za privabljanje morskih psov so bili uporabljeni deli razkosanih različnih rib. Med 23 dnevi, ki jih je ekspedicija prebila na morju, so bili psi privabljani 308,5 ur, rezultat pa je bil ta, da je bilo zabeleženih le 9 sinjih morskih psov Prionace glauca*, kar je izredno zaskrbljujoče, saj kaže, da so populacije morskih psov v srednjem Jadranu še bolj zdesetkane, kot je bilo pričakovati.*

Ključne besede: morski psi, privabljanje z razkosanimi ribami, Jadransko morje

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FIRST RECORD OF THE PIGEYE SHARK, *CARCHARHINUS AMBOINENSIS* (MÜLLER & HENLE, 1839), IN THE MEDITERRANEAN SEA

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ABSTRACT

The authors report herewith on the first Mediterranean record of the pigeye or Java shark, Carcharhinus amboinensis *(Müller & Henle, 1839). The specimen, estimated to be about 3 m long, was captured by a commercial fisherman in summer 2003, off Crotone, Italy, in the North-West Ionian Sea (Central Mediterranean). A description and morphometric measurements of its jaws are given. This record brings the number of shark species so far recorded in the Mediterranean Sea to 51.*

Key words: pigeye shark, Java shark, *Carcharhinus amboinensis*, Italy, Mediterranean Sea, Ionian Sea

PRIMA REGISTRAZIONE DI SQUALO OCCHIO DI PORCO, *CARCHARHINUS AMBOINENSIS* (MÜLLER & HENLE, 1839), NEL MARE MEDITERRANEO

SINTESI

Viene riportata la prima cattura in acque Mediterranee di squalo occhio di porco o squalo di Giava, Carcharhinus amboinensis *(Müller & Henle, 1839). L'esemplare, di lunghezza stimata intorno a 3 m, è stato pescato durante operazioni di pesca commerciale nell'estate 2003, al largo di Crotone, Italia, nel Mare Ionio Nord-Occidentale (Mediterraneo Centrale). Vengono presentate descrizione e misure morfometriche delle mascelle. Questo caso porta a 51 il numero delle specie di squali registrate sino ad oggi nel Mare Mediterraneo.*

Parole chiave: squalo dall'occhio di porco, squalo di Giava, *Carcharhinus amboinensis*, Italia, Mare Mediterraneo, Mar Ionio

INTRODUCTION

To date, 50 shark species have been recorded in the Mediterranean Sea. Of these 50 species, the following 11 are requiem sharks belonging to the genus *Carcharhinus* Blainville, 1816: strait shark, *Carcharhinus acarenatus* Moreno & Hoyos, 1983, bignose shark, *C. altimus* (Springer, 1950), copper shark, *C. brachyurus* (Günther, 1870), spinner shark, *C. brevipinna* (Müller & Henle, 1839), silky shark, *C. falciformis* (Bibron, 1839), blacktip shark, *C. limbatus* (Valenciennes, 1839), oceanic whitetip shark, *C. longimanus* (Poey, 1861), blacktip reef shark, *C. melanopterus* (Quoy & Gaimard, 1824), dusky shark, *C. obscurus* (Le Sueur, 1818), sandbar shark, *C. plumbeus* (Nardo, 1827), night shark, *C. signatus* (Poey, 1868) (Lo Bianco, 1909; Tortonese, 1938, 1956, 1987; Bigelow & Schroeder, 1948; Ben-Tuvia, 1953, 1971; George *et al.*, 1964; Capapé, 1974, 1989; Mouneimne, 1977; Capapé *et al.*, 1979; Cadenat & Blache, 1981; Garrick, 1982; Cigala Fulgosi, 1983; Moreno & Hoyos, 1983a, 1983b; Compagno, 1984; Muñoz-Chapuli, 1984; Bauchot, 1987; Moreno, 1987, 1995; Pastore & Prato, 1989; Golani, 1996; Vacchi *et al.*, 1996; Kovačić, 1998; Orsi Relini, 1998; Fergusson & Compagno, 2000; Lipej *et al.*, 2000, 2004; Barrull & Mate, 2002; Hemida *et al.*, 2002; Lipej *et al.*, 2004; Morey & Massuttí, 2004; De Maddalena & Bänsch, 2005). We report here on the first Mediterranean record of another species of the genus *Carcharhinus*, the pigeye shark or Java shark, *C. amboinensis* (Müller & Henle, 1839).

MATERIAL AND METHODS

In summer 2003, a large requiem shark was captured as by-catch during commercial fishery operations, off Crotone, Italy, (39°5′9′′ N, 17°7′6′′ E), in the North-West Ionian Sea (Central Mediterranean Sea). The total length of the specimen was not accurately measured, but it was estimated to be about 3 m long. Analysis of its stomach content was not performed. Its jaws were preserved by the fisherman that caught it and later acquired by one of the authors.

The jaws of the requiem shark were examined and the species was identified on the basis of Cadenat & Blache (1981), Compagno (1984), Last & Stevens (1994), Heim (2001), Šanda & De Maddalena (2004). Additional confirmation of the proper species identification has been kindly provided by Dr. Geremy Cliff and Dr. Bill Heim through examination of the shark jaw collections at their disposal.

Morphometric measurements were made of the jaws and teeth following methods of Mollet *et al.* (1996) and Compagno (1984).

RESULTS AND DISCUSSION

The specimen was identified as *C. amboinensis* based on the set of jaws (Fig. 1). The upper teeth are large, broad, triangular and strongly serrated, with no cusplets. The lower teeth are large, broad, triangular and serrated, with no cusplets. There are five rows of teeth in each jaw. The teeth exhibit the typical shape of requiem sharks; but the lower wide, conspicuously serrated teeth immediately permit the conclusion that the species is not one of those previously recorded in the Mediterranean. The teeth are very similar to those of the bull shark, *C. leucas* (Valenciennes, 1839), however, *C. leucas* has larger upper teeth and more elongated lower teeth, while *C. amboinensis* lower teeth are more triangular. Tooth count in the pigeye shark caught in the Ionian Sea is 12 – 1 – 12 / 11 – 1 – 11, that is the typical dental formula of *C. amboinensis* (with variability 11 to 13 – 11 to 13 / 10 to 12 – 10 to 12 omitting the small symphyseal teeth) (Compagno, 1984; Randall, 1986; B. Heim, *pers. comm.*). Measurements of the jaws of the pigeye shark are presented in Table 1.

This capture of *C. amboinensis* is the first record of its occurrence in the Mediterranean Sea. The geographical distribution of *C. amboinensis* is as follows: in the Eastern Atlantic it has been recorded in Nigeria; in the Indo-West Pacific it includes South Africa, Madagascar, Gulf of Aden, Pakistan, Sri Lanka, Indonesia and Australia (Compagno, 1984). However, this shark is probably more common throughout the world's oceans than the

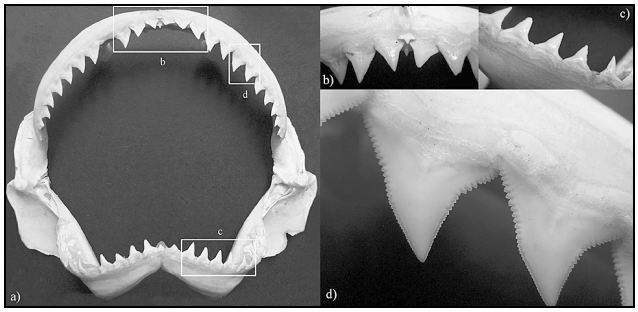

Fig. 1: Jaws of a pigeye shark, *Carcharhinus amboinensis* ***(Müller & Henle, 1839), caught in summer 2003 off Crotone, Italy, North-West Ionian Sea (Central Mediterranean Sea). (a) complete set of jaws; (b) symphyseal, first and second upper teeth; (c) second to sixth lower teeth; (d) sixth and seventh upper teeth. (Photo: A. De Maddalena)***

Sl. 1: Čeljusti javanskega morskega psa *Carcharhinus amboinensis* ***(Müller & Henle, 1839), ujetega poleti 2003 v severozahodnem Jonskem morju v bližini kalabrijskega mesta Crotone. (a) celotna čeljust; (b) zraščena prvi in drugi gornji zob; (c) drugi do šesti spodnji zobje; (d) šesti in sedmi gornji zob. (Foto: A. De Maddalena)***

Tab. 1: Measurements of the jaws of a pigeye shark, *Carcharhinus amboinensis* ***(Müller & Henle, 1839), caught off Crotone, Italy, North-West Ionian Sea (Central Mediterranean Sea).***
Tab. 1: Dimenzije čeljusti javanskega morskega psa *Carcharhinus amboinensis* ***(Müller & Henle, 1839), ujetega v severozahodnem Jonskem morje nedaleč od italijanskega obalnega mesta Crotone (srednje Sredozemsko morje).***

Parameter	Abbreviation	Measures(mm)
dried upper jaw perimeter	DUJP	415
dried lower jaw perimeter	DLJP	385
mouth width	MOW	215
enamel length of the second upper tooth	UA2E1	11
enamel length of the second lower tooth	LA2E1	10.5

few recorded catches would indicate. Many authors have confused this species with *C. leucas*, both being heavy-bodied, short-snouted sharks with similar morphology, colouration and dentition (Randall, 1986). The recent history of the Mediterranean Sea, its tropicalisation, the change from a warm temperate to a tropical regime connected to global warming we are currently experiencing, has seen a significant increase in the number of tropical species. The opening of the Suez Canal in 1869 has provided a means of ingression for Red Sea and Indo-Pacific sharks. *C. amboinensis* must be considered a lessepsian migrant.

This record brings the number of shark species recorded so far in the Mediterranean Sea to 51, the number of species of the genus *Carcharhinus* frequenting at least occasionally these waters to 12, and the number of shark species recorded in Italian waters to 43.

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Very special thanks to all the people who offered their help in collecting data and general information for this work: fishermen of Crotone, Bill Heim and Geremy Cliff. Special thanks to Alex Barron, who kindly edited the English text of this work. We also thank the referees for their helpful comments. Particular thanks from Alessandro De Maddalena go to his wife Alessandra and to his son Antonio.

PRVI PODATEK O POJAVLJANJU JAVANSKEGA MORSKEGA PSA *CARCHARHINUS AMBOINENSIS* (MÜLLER & HENLE, 1839) V SREDOZEMSKEM MORJU

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SUMMARY

Avtorja pričujočega prispevka poročata o prvem pojavljanju javanskega morskega psa Carcharhinus amboinensis *(Müller & Henle, 1839) v Sredozemskem morju. Približno 3 m dolgega psa je poleti 2003 ujel poklicni ribič v severozahodnem Jonskem morju nedaleč od kalabrijskega obalnega mesta Crotone. Avtorja podajata opis in dimenzije čeljusti ujetega primerka. S tem podatkom se je število vrst morskih psov, doslej ujetih v Sredozemskem morju, povzpelo na 51.*

Ključne besede: javanski morski pes, *Carcharhinus amboinensis*, Italija, Sredozemsko morje, Jonsko morje

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DEVELOPMENT OF THE INVASIVE TURF-FORMING RED ALGAE *WOMERSLEYELLA SETACEA* (HOLLENBERG) R. E. NORRIS ON SUBTIDAL SHORES OF RIJEKA BAY (NORTHERN ADRIATIC SEA)

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ABSTRACT

Results of the study of subtidal macrobenthic flora, carried out in 1997 at Cape Oštro, Rijeka Bay, Croatia (northern Adriatic Sea), are presented. The investigation was based on seasonal sampling at different depths. Results indicated that the flora was strongly dominated by turf-forming algae. Overall, 37 macrobenthic algae (23 Rhodophycota or 62.2%, 6 Phaeophycota or 16.2% and 8 Chlorophycota or 21.6%) were identified. The invasive red filamentous alga Womersleyella setacea *(Hollenberg) R. E. Norris was recorded for the first time in this area. The impact of massive development of the turf–forming algae on the structure of algal assemblages is discussed.*

Key words: turf-forming algae, *Womersleyella setacea*, subtidal, northern Adriatic Sea, Rijeka Bay

SVILUPPO DI FELTRI DELL'ALGA ROSSA INVASIVA *WOMERSLEYELLA SETACEA* (HOLLENBERG) R. E. NORRIS NELL'INFRALITORALE DEL GOLFO DI FIUME (ALTO ADRIATICO)

SINTESI

Vengono presentati i risultati di un'indagine condotta nel 1997 sulla flora macrobentonica nell'infralitorale nei pressi di Punta Oštro, Golfo di Fiume, Croazia (Alto Adriatico). Lo studio si basa su rilievi stagionali svolti a diverse profondità. I risultati indicano che la flora è costituita da densi feltri algali. Nel corso della ricerca sono state identificate 37 specie di alghe macrobentoniche, di cui 23 Rhodophycota (62,2%), 6 Phaeophycota (16,2%) e 8 Chlorophycota (21,6%). Nel presente lavoro viene segnalata per la prima volta in quest'area la presenza dell'alga rossa filamentosa invasiva Womersleyella setacea *(Hollenberg) R. E. Norris. Sono discusse le conseguenze dell'estesa diffusione di tali feltri sulla struttura delle comunità algali.*

Parole chiave: feltri algali, *Womersleyella setacea*, infralitorale, Alto Adriatico, Golfo di Fiume

INTRODUCTION

More than 90 taxa of marine algae are known to have been introduced into the Mediterranean Sea, mostly by human activities (*i.e.* aquaculture, pollution, ballast waters, fishing nets), and at least nine of them are considered invasive (Verlaque, 1994; Boudouresque & Verlaque, 2002). Some of the most invasive introductions took place in the last 10-15 years and have caused substantial changes in the structure of benthic algal assemblages. One of the best examples of this phenomenon is represented by the massive development of dense algal turfs produced by filamentous species, in particular the red alga *Womersleyella setacea* (Hollenberg) R. E. Norris This species has been reported to produce thick turfs covering large portions of subtidal bottoms in several regions (Verlaque, 1989; Airoldi *et al.*, 1995; Athanasiadis, 1997; Patzner, 1998). The uncontrolled growth of turfs is considered an indicator of disturbance in the environment, with a negative impact on biodiversity (Barth & Fagan, 1990; Morand & Briand, 1996).

Many non-indigenous species of algae have been recorded in the northern Adriatic Sea (Orlando Bonaca, 2001), mostly on the Italian shores. Among them, the brown *Sargassum muticum* (Yendo) Fensholt (Gargiulo *et al.*, 1992) and *Undaria pinnatifida* (Harvey) Surigar (Rismondo *et al.*, 1993), the green *Codium fragile* subsp. *tomentosoides* (Van Goor) P.C. Silva (Godini & Avanzini, 1988), *Caulerpa taxifolia* (Vahl) C. Agardh (Žuljević & Antolić, 1998; Špan *et al.*, 1998), *Ulva scandinavica* Bliding (Battelli & Tan, 1998), and the red *Antithamnion pectinatum* (Montagne) Brauner *ex* Athanasiadis et Tittley (Curiel *et al.*, 1996) and *Polysiphonia morrowii* Harvey (Curiel *et al.*, 2002) are some of the most recent records. Comparatively, the eastern shores of the northern Adriatic Sea have not been severely affected by algal introductions so far. However, some algae reported elsewhere as highly aggressive invaders, such as *C. taxifolia*, *Caulerpa racemosa* var. *cylindracea* (Sonder) Verlaque, Huisman & Boudouresque, (Verlaque, 1994) and *W. setacea* (Sartoni & Rossi, 1998), have been recently recorded.

In 1996, an extensive growth of turf-forming algae was noted in the sublittoral area around Cape Oštro, north-eastern coast of Rijeka Bay, northern Adriatic Sea (Battelli & Arko Pijevac, 2003). The same phenomenon was subsequently recorded in other parts of Rijeka Bay, such as the Sepen cove and the submarine area of Sv. Marko islet (Jaklin & Arko Pijevac, 1997; Zahtila, 1999). Examination of samples collected in these areas indicated that algal turfs had been formed primarily by *W. setacea*. The benthic marine algae of the Kvarner Gulf have been studied sporadically (Munda, 1960; Rizzi Longo, 1972; Zavodnik *et al.*, 1981; Zavodnik & Zavodnik, 1982; Zavodnik, 1992; Zavodnik *et al.*, 1998) and no previous records of this phenomenon are available in the literature.

In this study, we report preliminary on the observations regarding the composition of algal assemblages, their bathymetric variation and the reproductive phenology of *W. setacea* in the area at Cape Oštro. The results presented constitute the first report on extensive development of algal turfs in the northern Adriatic and provide a background of knowledge that will be of great value for further investigations.

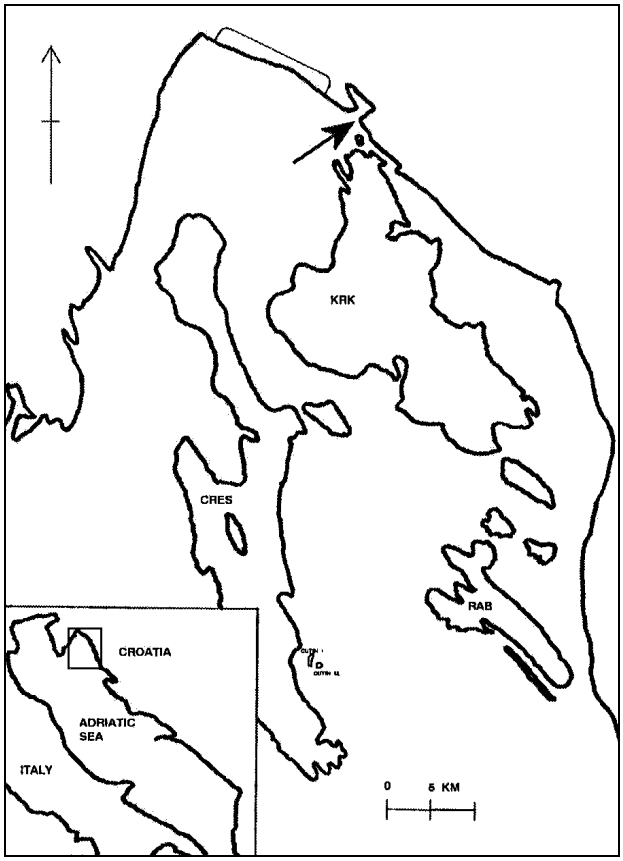

Fig. 1: Study area, Cape Oštro (north-eastern coast of Rijeka Bay).
Sl. 1: Raziskovano območje, Rt Oštro (severovzhodna obala Reškega zaliva).

MATERIAL AND METHODS

The study was carried out near Cape Oštro (north-eastern coast of Rijeka Bay) (43°16.152 N, 14°33.792 E) in 1997 (Fig. 1). The morphology of the area's bottom varies with depth; the substratum consists of carbonate rocks (limestone and dolomites) between 0 and 5 m, a mixture of rock and sand between 5 and 10 m, sand between 10 and 15 m, and muddy sand below 15 m.

Samples were collected at different depths (5, 10, 15 and 20 m) and in each season. Overall, 36 samples (8 in winter, 8 in summer, 8 in autumn and 12 in spring) were collected. Algae were removed from 100 cm^2 squares

and the percentage cover of each species was estimated for each date and for different depths (5 m, 10 m, 15 m and 20 m). The samples were preserved in 4% seawater-formalin solution and examined in the laboratory. The algal material is deposited in the Natural History Museum of Rijeka.

The algae were determined at the best possible level of taxonomic resolution; for *W. setacea* (Fig. 2), detailed observations of the reproductive phenology were also carried out. Algal nomenclature follows Ribera *et al.* (1992), Gallardo *et al.* (1993), and Gómez Garreta *et al.* (2001).

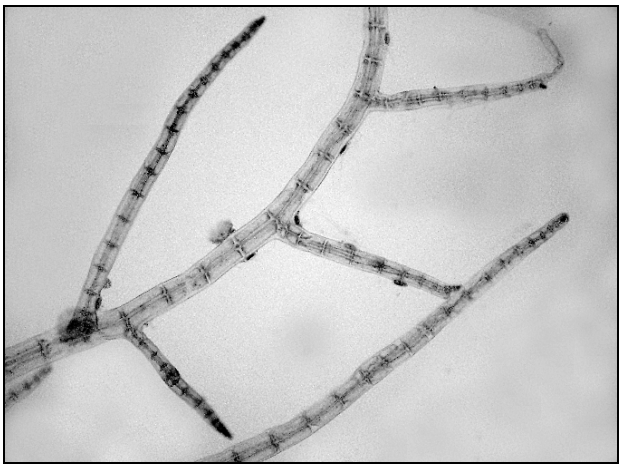

Fig. 2: Thallus of *Womersleyella setacea* ***(barr = 500 µm).***
Sl. 2: Steljka vrste *Womersleyella setacea* ***(merilo = 500 µm).***

RESULTS

Overall, 37 species of macrobenthic algae were identified (Tab. 1): 23 Rhodophycota (62.2%), 6 Phaeophycota (16.2%) and 8 Chlorophycota (21.6%).

At the time of the survey, the bottom of the surveyed area was colonized by macroalgal assemblages that appeared very poor in terms of species number. The investigated area was mostly colonized by turf-forming species overgrowing all types of substrata from 5 m to 20 m depth.

In terms of presence, the most common species were the green algae *Chaetomorpha linum* (O.F. Müller) Kützing and *Cladophora nigrescens* Zanardini *ex* Frauenfeld and the red alga *Womersleyella setacea*. The species *C. linum* dominated at a depth of 5 m, *C. nigrescens* at depths of 10 and 20 m, while the depth of 15 m was dominated by the red alga *W. setacea* (Tabs. 2, 3, 4, 5).

Tab. 1: Check list of macrobenthic algae at Cape Oštro (Rijeka Bay, northern Adriatic Sea).
Tab. 1: Seznam vrst makrobentoških alg pri Rtu Oštro (Reški zaliv, severno Jadransko morje).

Rhodophycota
Antithamnion cruciatum (C. Agardh) Nägeli
Boergeseniella fruticulosa (Wulfen) Kylin
Ceramium ciliatum (J. Ellis) Ducluzeau var. *robustum* (J. Agardh) Feldmann-Mazoyer
Ceramium tenerrimum (G. Martens) Okamura
Champia parvula (C. Agardh) Harvey
Chondria coerulescens (J. Agardh) Falkenberg
Dipterosiphonia rigens (C. Agardh) Falkenberg
Gelidium pusillum (Stackhouse) Le Jolis
Haliptilon virgatum (Zanardini) Garbary *et* H. V. Johansen
Halopithys incurva (Hudson) Batters
Herposiphonia secunda (C. Agardh) Ambronn f. *secunda*
Jania rubens (Linnaeus) J. V. Lamouroux
Laurencia sp.
Lophosiphonia obscura (C. Agardh) Falkenberg
Nitophyllum punctatum (Stackhouse) Greville
Polysiphonia atra Zanardini
Polysiphonia breviarticulata (C. Agardh) Zanardini
Polysiphonia opaca (C. Agardh) Moris & De Notaris
Polysiphonia polyspora (C.Agardh) Montagne
Polysiphonia stuposa Zanardini ex Kützing
Polysiphonia subulifera (C. Agardh) Harvey
Spyridia filamentosa (Wulfen) Harvey
Womersleyella setacea (Hollenberg) R. E. Norris
Phaeophycota
Cystoseira corniculata (Turner) Zanardini
Dictyota dichotoma (Hudson) J.V. Lamouroux var *dichotoma*
Dictyota fasciola (Roth) J.V.Lamouroux
Halopteris filicina (Grateloup) Kützing
Padina pavonica (Linnaeus) J. V. Lamouroux
Sphacelaria cirrosa (Roth) C. Agardh
Chlorophycota
Chaetomorpha linum (O. F. Mueller) Kützin
Cladophora coelothrix Kützing
Cladophora laetevirens (Dillwin) Kützing
Cladophora lehmanniana (Lindenberg) Kützing
Cladophora nigrescens Zanardini ex Frauenfeld
Cladophora prolifera (Roth) Kützing
Ulva clathrata (Roth) C. Agardh
Ulva laetevirens Areschoug

In terms of percentage cover, the most abundant species were the green algae *C. nigrescens* and the red alga *W. setacea*. During the study, the abundance of *C. nigrescens*, at different depths, was generally higher than *W. setacea*, although the average cover percentage of these two species showed different trends during the seasons. The cover percentage of *C. nigrescens* increased from a depth of 5 m to a depth of 10 m and then markedly decreased to a depth of 20 m. The fluctuation of the cover percentage of the red algae *W. setacea* showed a different trend: it increased slightly from a depth of 5 m to 15 m and then decreased at a depth of 20 m (Fig. 3).

Seasonal fluctuation of the cover percentage values showed that at all depths (5 m, 10 m, 15 m, 20 m), the abundance of *C. nigrescens* decreased in general from the winter to the summer and then increased in the autumn, while the abundance of *W. setacea* slightly decreased from the winter to the autumn at all depths (Fig. 4).

In spite of frequent sampling, *W. setacea* was never observed in a reproductive state.

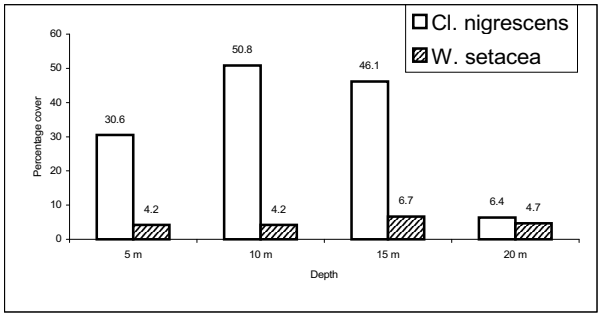

Fig. 3: Percentage covers of** C. nigrescens **and** W. setacea **at different depths.
Sl. 3: Odstotne pokrovne vrednosti vrst** C. nigrescens **in** W. setacea **na različnih globinah.

DISCUSSION

During the study, the invasive filamentous red alga *W. setacea* was recorded for the first time in Rijeka Bay. This species, originally described from a tropical locality and subsequently reported for other tropical regions, has recently become widespread in the Mediterranean Sea (Verlaque, 1989, 1994; Airoldi *et al.*, 1994; Rindi & Cinelli, 1995; Athanasiadis, 1997; Rindi *et al.*, 1999), and in the northern Adriatic Sea (Sartoni & Rossi, 1998).

The phenological observations suggest that the colonization of *W. setacea* proceeded by vegetative reproduction, which is so far the only form of reproduction known both in the field and in cultures of this species from various areas of the Mediterranean Sea (Airoldi *et al.*,1995; Rindi *et al.*, 1999; Rindi & Cinelli, 2000).

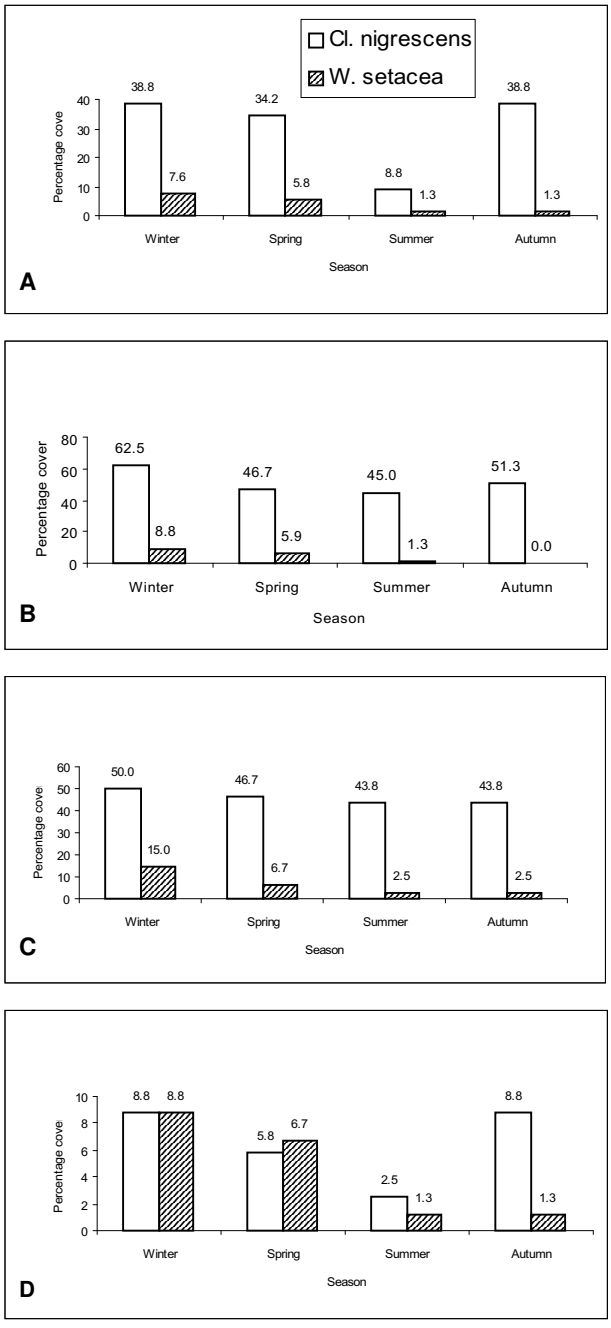

Fig. 4: Temporal fluctuation of mean cover of** C. nigrescens **and** W. setacea **at a depth of (A) 5 m, (B) 10 m, (C) 15 m and (D) 20 m.
Sl. 4: Sezonske variacije pokrovnih vrednosti vrst** C. nigrescens **in** W. setacea **na globini (A) 5 m, (B) 10 m, (C) 15 m in (D) 20 m.

The present results show that turfs of *W. setacea* can grow on all types of substratum (rock, sand and mud) and at different depths in the investigated area. Although *W. setacea* has been recorded in the Adriatic only re-

cently, the extensive development of this alga in Rijeka Bay reflects the fast and aggressive propagation already reported for the western Mediterranean Sea (Verlaque, 1989; Airoldi *et al.*, 1995; Athanasiadis, 1997; Rindi & Cinelli, 2000; Piazzi & Cinelli, 2001; Boudouresque & Verlaque, 2002).

Tab. 2: Algal species recorded in the study area at a depth of 5 m with average values*. (*Cover abundance values)
Tab. 2: Vrste alg na raziskanem območju na globini 5 m s pokrovnimi vrednostmi*. (*Vrednosti pokrovne gostote)

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Nov	Dec
A. cruciatum	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
B. fruticulosa	15.0	2.5	2.5	0.0	0.0	15.0	0.0	2.5	0.0
C. ciliatum v. *robustum*	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
C. coerulescens	15.0	2.5	2.5	2.5	0.0	0.0	0.0	2.5	0.0
C. laetevirens	0.0	0.0	0.0	0.0	15.0	0.0	0.0	0.0	2.5
C. tenerrimum	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1
Ch. linum	0.1	2.5	0.1	0.1	2.5	0.1	0.1	0.1	0.1
Cl. coelothrix	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cl. lehmanniana	0.0	0.0	0.1	0.0	15.0	0.0	2.5	0.0	0.0
Cl. nigrescens	62.5	15.0	0.0	87.5	15.0	15.0	2.5	62.5	15.0
Cl. prolifera	0.1	0.1	0.1	2.5	0.0	2.5	0.0	2.5	0.0
Cy. corniculata	0.0	0.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0
D. dichotoma	2.5	15.0	15.0	0.0	0.0	0.1	0.0	0.0	15.0
D. fasciola	2.5	0.1	0.1	0.0	15.0	0.1	15.0	2.5	15.0
D. rigens	0.0	0.0	2.5	0.0	2.5	2.5	15.0	2.5	0.0
G. pusillum	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H. filicina	0.0	0.1	0.0	0.0	0.0	2.5	0.0	0.0	0.0
H. incurva	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0
H. secunda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
L. obscura	0.0	2.5	0.0	0.1	2.5	0.0	0.1	0.1	0.0
Laurencia sp.	0.0	0.0	15.0	2.5	15.0	15.0	15.0	15.0	0.0
N. punctatum	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P. atra	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
P. breviarticulata	0.0	0.0	2.5	0.1	0.1	2.5	2.5	2.5	0.1
P. opaca	0.1	2.5	0.0	0.1	0.1	0.0	0.1	2.5	0.0
P. polyspora	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5
P. sertularioides	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
P. stuposa	0.0	2.5	2.5	0.0	2.5	0.0	0.1	0.0	0.0
P. subulifera	0.0	15.0	2.5	0.0	0.1	0.0	0.0	0.0	2.5
S. filamentosa	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	2.5
Sp. cirrosa	0.1	0.1	0.0	0.0	2.5	0.1	2.5	2.5	0.0
W. setacea	0.1	15.0	15.0	0.0	2.5	0.1	2.5	0.0	2.5

*Cover abundance values / Vrednosti pokrovne gostote:

Class	% cover	Average values
+	<1%	0.1
1	1.1–5.0%	2.5
2	5.1–25.0%	15.0
3	25.1–50.0%	37.5
4	50.1–75.0%	62.5
5	75.1–100%	87.5

In the course of the survey, large-sized erect algae appeared to be rare. The high dominance of the turf-forming algae might negatively affect the development of some erect species, such as *Dictyota dichotoma* (Hudson) J. V. Lamouroux, *Dictyota fasciola* (Roth) J. V. Lamouroux, *Padina pavonica* (Linnaeus) J. V. Lamouroux and *Cystoseira corniculata* (Turner) Zanardini. This is in agreement with the studies carried out in other regions of the Mediterranean, which have shown that the monopolization of substratum by turf-forming filamentous algae can prevent the development of other macroalgae by overgrowth and accumulation of sediment, making the settlement of spores and the survival of juvenile stages impossible and thus reducing species diversity and equitability (Airoldi *et al.,* 1995; Morand & Briand, 1996; Airoldi & Virgilio, 1998; Piazzi & Cinelli, 2001).

The present observations, however, are based on a relatively short sampling period and do not allow for a formulation of relevant conclusions on the impact of these algal turfs in Rijeka Bay. Observations in a longer temporal span and studies based on an experimental approach, as carried out for other parts of the Mediter-

Tab. 3: Algal species recorded in the study area at a depth of 10 m with average values*. (*see Table 2)
Tab. 3: Vrste alg na raziskanem območju na globini 10 m s pokrovnimi vrednostmi*. (*glej Tabelo 2)

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Nov	Dec
C. coerulescens	2.5	0.1	0.1	2.5	0.0	2.5	0.0	0.1	2.5
C. parvula	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Ce. ciliatum v. *robustum*	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0
Ce. tenerrimum	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0
Ch. linum	0.1	2.5	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Cl. laetevirens	0.0	37.5	15.0	0.0	0.0	2.5	0.0	0.0	0.0
Cl. lehmanniana	0.0	0.1	0.0	0.0	0.0	0.0	2.5	2.5	2.5
Cl. nigrescens	87.5	37.5	15.0	87.5	37.5	87.5	2.5	87.5	15.0
Cl. prolifera	2.5	0.0	0.0	0.0	2.5	2.5	2.5	0.0	0.5
Cy. corniculata	0.0	0.0	0.0	0.0	0.0	0.0	62.5	0.0	0.0
D. dichotoma	0.0	0.1	0.1	2.5	0.0	0.0	0.0	0.0	0.0
D. fasciola	0.0	2.5	0.0	2.5	0.0	0.0	15.0	0.0	2.5
D. rigens	2.5	0.1	0.1	0.0	0.0	0.0	2.5	0.0	2.5
G. pusillum	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
H. filicina	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
H. incurva	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0
L. obscura	0.0	2.5	0.1	0.0	0.0	0.1	0.0	2.5	0.0
Laurencia sp.	0.0	0.1	0.0	2.5	0.1	0.0	0.1	0.0	0.0
P. atra	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P. breviarticulata	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	2.5
P. opaca	0.0	0.1	0.0	0.0	0.1	0.0	0.1	0.1	0.1
P. polyspora	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
P. sertularioides	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
P. stuposa	0.0	0.0	0.0	0.0	0.1	0.0	2.5	0.0	0.0
P. subulifera	0.0	0.0	2.5	0.0	0.1	0.0	0.0	0.0	2.5
S. filamentosa	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
Sp. cirrosa	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
W. setacea	2.5	15.0	15.0	0.1	2.5	0.0	2.5	0.0	0.0

Tab. 4: Algal species recorded in the study area at a depth of 15 m with average values*. (*see Table 2)
Tab. 4: Vrste alg na raziskanem območju na globini 15 m s pokrovnimi vrednostmi*. (*glej Tabelo 2)

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Nov	Dec
B. fruticulosa	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
C. coerulescens	0.0	2.5	2.5	0.1	0.0	2.5	0.0	2.5	0.0
Ce. tenerrimum	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Ch. linum	0.1	2.5	2.5	0.1	2.5	0.1	0.0	0.1	0.1
Cl. nigrescens	62.5	37.5	37.5	87.5	15.0	87.5	0.0	87.5	0.0
Cl. laetevirens	0.0	15.0	15.0	0.0	0.0	0.1	15.0	2.5	0.0
Cl. lehmanniana	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	2.5
Cl. prolifera	2.5	0.1	2.5	2.5	0.1	0.0	0.0	0.0	0.1
Cy. corniculata	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.0	0.0
D. dichotoma	0.0	0.1	0.0	0.1	0.0	0.0	15.0	0.0	0.0
D. rigens	0.0	0.1	0.0	0.0	0.0	0.0	2.5	0.0	2.5
H. incurva	0.1	2.5	0.1	0.0	0.1	0.0	0.0	0.0	0.0
L. obscura	2.5	2.5	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Laurencia sp.	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P. atra	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P. opaca	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
P. sertularioides	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
P. stuposa	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.1
P. subulifera	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	2.5
S. cirrosa	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
S. filamentosa	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
W. setacea	15.0	15.0	15.0	2.5	2.5	2.5	2.5	2.5	2.5

ranean, will be necessary to understand better the effects of the development of algal turfs. It is therefore very important that the scientific institutions continue to monitor the distribution and persistence of turfs of *W. setacea* and their effects on the structure of subtidal assemblages.

Tab. 5: Algal species recorded in the study area at a depth of 20 m with average values*. (*see Table 2)
Tab. 5: Vrste alg na raziskanem območju na globini 20 m s pokrovnimi vrednostmi*. (*glej Tabelo 2)

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Nov	Dec
B. fruticulosa	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ce. ciliatum v. *robustum*	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Ch. linum	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.1
Cl. lehmanniana	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Cl. nigrescens	15.0	2.5	0.0	15.0	2.5	2.5	2.5	2.5	15.0
Cl. prolifera	2.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D. dichotoma	0.0	0.0	2.5	0.0	15.0	0.1	0.1	0.1	0.0
D. rigens	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0
H. filicina	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H. incurva	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0
H. secunda	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Laurencia sp.	0.0	0.1	0.0	0.0	15.0	2.5	0.1	2.5	0.0
P. atra	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P. pavonica	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0
P. stuposa	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
S. cirrosa	0.1	0.0	2.5	0.0	2.5	0.1	0.1	0.1	0.0
U. clathrata	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
W. setacea	2.5	15.0	2.5	15.0	2.5	2.5	0.0	0.0	2.5

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POJAVLJANJE GOSTIH PREVLEK INVAZIVNE RDEČE ALGE *WOMERSLEYELLA SETACEA* (HOLLENBERG) R. E. NORRIS V INFRALITORALU REŠKEGA ZALIVA (SEVERNO JADRANSKO MORJE)

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POVZETEK

Članek obravnava rezultate raziskave morske makrobentoške flore alg infralitorala pri rtu Oštro, Reški zaliv (severno Jadransko morje). Študija, napravljena v letu 1997, temelji na sezonskem vzorčenju na različnih globinah (5, 10, 15 in 20 m). Rezultati kažejo, da je flora alg sestavljena predvsem iz gostih prevlek makrobentoških alg. Skupno je bilo določenih 37 alg, med katerimi je bilo 23 rdečih (62,2%), 6 rjavih (16,2%) in 8 zelenih (21,6%). Prikazana je časovna variacija pokrovnih vrednosti najbolj pogostih vrst (Cladophora nigrescens *Zanardini ex Frauenfeld in*

Womersleyella setacea *(Hollenberg) R. E. Norris). V članku je prvič zabeleženo pojavljanje rdeče nitaste alge* W. setacea *na tem območju, ki se tu pojavlja na vseh globinah in v vseh letnih časih, vendar nikoli v fertilni obliki. Dosedanje študije o vrsti* W. setacea *so pokazale, da se vrsta v Sredozemskem morju razmnožuje vegetativno in hitro širi po vseh vrstah podlage; zato se ta alga prišteva k invazivnim vrstam. Članek obravnava tudi posledice masivnega pojavljanja gostih prevlek makrobentoških alg na sestavo združb alg.*

Ključne besede: prevleke alg, *Womersleyella setacea,* infralitoral, severno Jadransko morje, Reški zaliv

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PHYTOGEOGRAPHY AND SYNTAXONOMY OF SNOW-BED VEGETATION ON CALCAREOUS SUBSTRATES IN THE SOUTH-EASTERN ALPS: A NUMERICAL APPROACH

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ABSTRACT

*Based on cluster analysis and the phytogeographic peculiarities of the area, an assessment of the vegetation of snow-beds on calcareous soils (*Arabidetalia caeruleae*) in the South-eastern Alps was made. Eight distinct associations belonging to three alliances were recognised:* Saxifragetum stellaro-sedoidis, Saxifragetum hohenwartii *and* Ranunculo traunfellneri-Festucetum nitidae *(alliance* Arabidion caeruleae*),* Salici herbaceae-Arabidetum caeruleae *(alliance* Salici herbaceae-Arabidion caeruleae*),* Salicetum retuso-reticulatae, Homogyno discoloris-Salicetum retusae, Salici retusae-Geranietum argentei *and* Potentillo brauneanae-Homogynetum discoloris *(alliance* Soldanello alpinae-Salicion retusae*).* Saxifragetum stellaro-sedoidis *was further subdivided into three geographical variants, such as variants of* Achillea oxyloba, Ranunculus traunfellneri *and* Campanula pulla. *The* Drepanoclado uncinati-Heliospermetum pusilli *from the Liburnian Karst (Dinaric Mts.) showed clear floristic and phytogeographic distinctions and its placement into the Dinaric alliance* Salicion retusae *was confirmed.*

Key words: biogeography, syntaxonomy, endemic species, cluster analysis, snow-beds, the Alps, *Arabidetalia caeruleae, Thlaspietea rotundifolii*

FITOGEOGRAFIA E SINTASSONOMIA DELLA VEGETAZIONE DEL MANTO NEVOSO SU SUBSTRATI CALCAREI NELLE ALPI SUD-ORIENTALI: APPROCCIO NUMERICO

SINTESI

*In base alla "cluster analysis" ed alle peculiarità fitogeografiche dell'area, gli autori hanno preparato una valutazione della vegetazione del manto nevoso di terreni calcarei (*Arabidetalia caeruleae*) delle Alpi sud-orientali. Otto associazioni distinte, appartenenti a tre alleanze, sono state riconosciute:* Saxifragetum stellaro-sedoidis, Saxifragetum hohenwartii *e* Ranunculo traunfellneri-Festucetum nitidae *(alleanza* Arabidion caeruleae*),* Salici herbaceae-Arabidetum caeruleae *(alleanza* Salici herbaceae-Arabidion caeruleae*),* Salicetum retuso-reticulatae, Homogyno discoloris-Salicetum retusae, Salici retusae-Geranietum argentei *e* Potentillo brauneanae-Homogynetum discoloris *(alleanza* Soldanello alpinae-Salicion retusae*).* Saxifragetum stellaro-sedoidis *è stato ulteriormente suddiviso in tre varianti geografiche, ossia le varianti di* Achillea oxyloba, Ranunculus traunfellneri *e* Campanula pulla. Drepanoclado uncinati-Heliospermetum pusilli *proveniente dal Carso liburniano (montagne dinariche) si è chiaramente distinto floristicamente e fitogeograficamente, ed è stata confermata la sua collocazione nell'alleanza dinarica* Salicion retusae.

Parole chiave: biogeografia, sintassonomia, specie endemiche, cluster analysis, snow-beds, Alpi, *Arabidetalia caeruleae, Thlaspietea rotundifolii*

INTRODUCTION

The order *Arabidetalia caeruleae* comprises pioneer or permanent hygrophilous stands occurring on more or less stabilised calcareous screes and moraines with a long duration of snow cover, and from the altimontane to subnival belt in Central and south-eastern Europe (Braun-Blanquet, 1926; Horvat, 1931; Englisch *et al.*, 1993). The floristic composition, ecology and physiognomy of *Arabidetalia* stands are relatively well characterised and distinctions from other scree stands are usually not questionable. Recently, a comprehensive study of the snow-bed vegetation in the Northern Calcareous Alps (Englisch, 1999) resulted in the recognition of three floristically and ecologically well defined alliances in the Alps, including the *Arabidion caeruleae, Salici herbaceae-Arabidion caeruleae* and *Soldanello alpinae-Salicion retusae*. However, although this study also included some of the relevés from the South-eastern Calcareous Alps, no similar treatise of syntaxa from *Arabidetalia* in the South-eastern Alps has yet been provided. The aim of the paper is thus to study, on the basis of a comprehensive synoptic table and cluster analyses, the ecology and syntaxonomy of the order, with an emphasis on the phytogeographic peculiarities of the area, as well as to summarise current knowledge on the phytosociology and ecology of syntaxa of *Arabidetalia* in the South and South-eastern Alps.

The phytogeographic peculiarities of the flora and vegetation of the South-eastern (Calcareous) Alps (Fig. 1) have been recognised for a long time. In comparison to other Alpine regions, they are characterised by a significant number of conservative, progressive, absolute and relative endemics, southern-, south-eastern – Alpine, north – Illyrian and Illyrian (Illyricoid) species (Engler, 1901; Mayer, 1960a, 1960b; Wraber, 1995; Tribsch & Schönswetter, 2003; Surina, 2004a). According to Pawlowski (1970), the South-eastern Calcareous Alps are floristically the second richest region of the Alps. The particularity of its flora and vegetation are due to their specific origin as a result of the historical, geographical and ecological peculiarities of the area.

The first phytosociological studies in the area on frigiphilous and hygrophilous scree vegetation were performed by Aichinger (1933: columns 1, 2, 14 in Table 1) in the Karavanke Mts. Further research in the South-eastern Calcareous Alps (Julian Alps, Kamnik Alps and the Karavanke Mts.) was implemented by Wraber (1972: 7, 8, 15) and Surina (2004c: 4, 12, 13) in the Julian Alps and by Haderlapp (1982: 14) in the Kamnik Alps. Poldini & Martini (1993: 17) studied the calcareous hygrophilous and frigiphilous snow-bed and talus slope vegetation in the Carnic Alps, Wikus (1959: 3, 9, 10) in the Dolomites of Lienz, and Lasen (1983: 18) in the Dolomites of Belluno, while Gerdol & Piccoli (1982: 18) engaged in its research in Monte Baldo. Pignatti & Pignatti (1983) studied the vegetation of Vette di Feltre (Dolomites of Belluno) and with two unpublished relevés identified the association *Salicetum retuso-reticulatae*. The same phytosociologists published an analysis and overview of the calcareous scree vegetation (*Thlaspietalia rotundifolii*) in the South-eastern Alps (Pignatti & Pignatti, 1984), while Wraber (1970) published a paper on vegetation of the SE Alps.

In comparison to the SE Alps, the snow-bed vegetation on calcareous soils in the Northern Calcareous Alps has been studied by many phytosociologists. The results were summarised by Englisch *et al.* (1993) and lately by Englisch (1999).

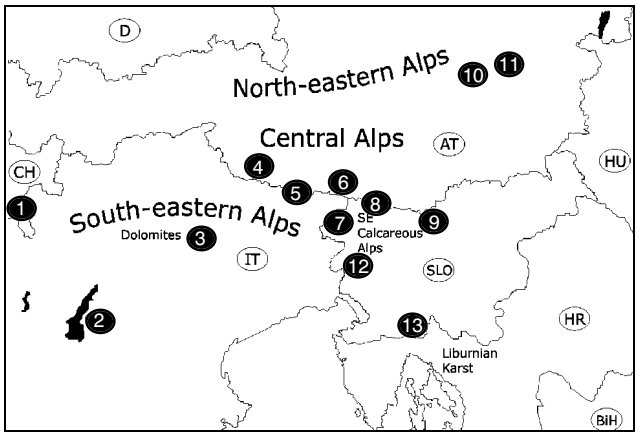

Fig. 1: Research area. 1 – Bernina; 2 – Monte Baldo; 3 – Dolomites of Belluno; 4 – Dolomites of Lienz; 5 – Carnic Alps; 6 – Mt. Dobrač; 7 – Julian Alps; 8 – Karavanke Mts.; 9 – Kamnik Alps; 10 – Gesäuse; 11 – Hochschwab; 12 – Trnovski gozd plateau; 13 – Mt. Snežnik.
Sl. 1: Raziskovano območje. 1 – Bernina; 2 – Monte Baldo; 3 – Bellunški Dolomiti; 4 – Lienški Dolomiti; 5 – Karnijske Alpe; 6 – Dobrač; 7 – Julijske Alpe; 8 – Karavanke; 9 – Kamniške Alpe; 10 – Gesäuse; 11 – Hochschwab; 12 – Trnovski gozd; 13 – Snežnik.

MATERIAL AND METHODS

Phytosociological research of calcareous scree vegetation of *Arabidetalia* was conducted by applying the sigmatistic method (Braun-Blanquet, 1964; Westhoff & Maarel, 1973; Dierschke, 1994). Altogether, 232 relevés from the SE Alps (between Monte Baldo and the Kamnik Alps) and NE Alps were used in the analysis (see the Appendix). With the aid of SYN-TAX 2000 computer programme (Podani, 2001) and a synoptic phytosociological table (Tab. 1), comparisons between stands were made after the transformation of cover-abundance values according to van der Maarel (1979) had been performed. The measure of dissimilarity was the complement of the "Similarity Ratio" coefficient. We used the Furthest Neighbour – Complete Linkage clustering

method (CL) and the Principal Coordinates Analysis (PCoA) ordination method. Coverage index ($D_{\%}$, see Surina, 2004b, 2005) was calculated for each taxon separately. Groups of diagnostic species were formed on the basis of our own criteria, but with regard to numerous authors. Three floristically and/or ecologically similar syntaxa were included in the analyses, *i.e. Saxifragetum hohenwartii (Thlaspion rotundifolii)* from the *Karavanke Mts., Poo supinae-Cerastietum cerastoidis (Salicion herbaceae, Salicetalia herbaceae)* from the Dolomites of Lienz, and *Drepanoclado uncinati-Heliospermetum pusilli* from the Liburnian Karst (*sensu* Beck, 1901) in the Dinaric Mts. Nomenclature of the syntaxa follows Englisch *et al.* (1993), Theurillat *et al.* (1995), Englisch (1999), and Aeschimann *et al.* (2004b); the list is given in the Appendix. Plant names and chorological groups are in agreement with the Flora alpina (Aeschimann *et al.*, 2004a) and the Register of the Flora of Slovenia (Trpin & Vreš, 1995).

Tab. 1: Synoptic table of syntaxa from the order *Arabidetalia caeruleae* ***s. lat. in the South-eastern and North-eastern Alps. 1, 2 –*** *Saxifragetum hohenwartii****; 3 –*** *Saxifragetum stellaro-sedoidis* ***var. geogr.*** *Achillea oxyloba****; 4 –*** *Saxifragetum stellaro-sedoidis* ***var. geogr.*** *Ranunculus traunfellneri****; 5, 6 –*** *Saxifragetum stellaro-sedoidis* ***var. geogr.*** *Campanula pulla****; 7, 8 –*** *Ranunculo traunfellneri-Festucetum nitidae****; 9 –*** *Poo supinae-Cerastietum cerastoidis****; 10 –*** *Salici herbaceae-Arabidetum coeruleae****; 11 -*** *Drepanoclado uncinati-Heliospermetum pusilli****; 12 –*** *Salici retusae-Geranietum argentei****; 13, 14 –*** *Homogyno discoloris-Salicetum retusae****; 15–17 –*** *Salicetum retuso-reticulatae****; 18, 19 –*** *Potentillo brauneanae-Homogynetum discoloris****.***

Tab. 1: Sinoptična tabela sintaksonov iz reda *Arabidetalia coeruleae* ***s. lat. v jugovzhodnih in severovzhodnih Alpah. 1, 2 –*** *Saxifragetum hohenwartii****; 3 –*** *Saxifragetum stellaro-sedoidis* ***var. geogr.*** *Achillea oxyloba****; 4 –*** *Saxifragetum stellaro-sedoidis* ***var. geogr.*** *Ranunculus traunfellneri****; 5, 6 –*** *Saxifragetum stellaro-sedoidis* ***var. geogr.*** *Campanula pulla****; 7, 8 –*** *Ranunculo traunfellneri-Festucetum nitidae****; 9 –*** *Poo supinae-Cerastietum cerastoidis****; 10 –*** *Salici herbaceae-Arabidetum coeruleae****; 11 –*** *Drepanoclado uncinati-Heliospermetum pusilli****; 12 –*** *Salici retusae-Geranietum argentei****; 13, 14 –*** *Homogyno discoloris-Salicetum retusae****; 15–17 –*** *Salicetum retuso-reticulatae****; 18, 19 –*** *Potentillo brauneanae-Homogynetum discoloris****.***

	Successive number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
	Syntaxa	Arabidion caeruleae s. lat.											Soldanello-Salicion retusae							
	No. of relevés	6	10	16	11	22	17	8	18	3	12	24	16	13	9	18	7	5	8	9
	No. of species	**26**	**33**	**39**	**42**	**39**	**47**	**41**	**72**	**22**	**54**	**58**	**88**	**86**	**65**	**97**	**56**	**42**	**66**	**39**
	Characteristic and differential (d) species																			
	Arabidion caeruleae (AC_3)																			
	Soldanella minima**	50	90	63	9				33		67		31	23	11	33	29		13	67
	Saxifraga androsacea	17	60	13	9	55	94	50	22	33	92			15	33	44		20	38	
	Saxifraga sedoides			100	100	100	100	75	39	67	33			15		17	43			
	Gnaphalium hoppeanum						6	38	28	100	100				11	33		80	25	100
	Hutchinsia alpina ssp. austroalpina*	83	90	75	64			75	33						11		14			11
	Hutchinsia alpina ssp. brevicaulis					100	88			100	33					33		20		
	Potentilla brauneana							38	56		83				11				88	100
	Thlaspi alpestre*		20			5	18						6	8		17				
	Arabis caerulea*						29	88	6	100	92									
	Saxifraga hohenwartii*	100	100	6											11					
	Rumex nivalis				18			63	89											
	Geographical differential species																			
TR_2	Achillea oxyloba*			75						100	83			8		33	43			
AC_2	Ranunculus traunfellneri**	83	40	6	64			63	72				25	62	44				38	
TR_2	Achillea clusiana*					5	29													
AC_3	Campanula pulla*					45	76									22				
ES	Viola calcarata ssp. calcarata**																	100		
SS	Soldanella alpina								44		42	4	56	38	44	44	29	100	50	44
	Soldanello alpinae-Salicion retusae (SS)																			
	Salix retusa		70	6		5	41	13	56		58		81	100	100	100	100	80	88	100
	Salix reticulata						24				33				11	78	100	40		

	Arabidetalia caeruleae (AC_2)																			
	Veronica aphylla		50	25	36	9		25	44		17		13	15	33	22		20	50	33
	Arabis alpina ssp. alpina	83	80	63	82	95	35	38	22			17		8	11					
	Carex atrata ssp. atrata				9		6					8	6	23	56	6	29	80		
	Carex parviflora				9		65	25	11				6	38		61	29		88	
	Carex ornithopodoides			6				13	6		58			15	11	6			75	
	Festuca nitida				55			38	100			4	50	38					50	
	Ranunculus alpestris				9	50	82				8					61	100	60		
	Anemone baldensis				10				33		8			15	33	11				
	Galium noricum**						41	38	17						11	39			63	
	Soldanella austriaca*					50	71									28				
	Doronicum glaciale ssp. calcareum*						18													
	Festuca rupicaprina*					9														
	Thlaspion rotundifolii (TR_3)																			
	Thlaspi rotundifolium ssp. rotundifolium*			56	9	5		50	33											
	Leontodon montanus ssp. montanus			19		5					25					11				
	Papaver aurantiacum			38				13												
	Papaver ernesti-mayeri							13	17											
	Alyssum ovirense							13												
	Minuartia austriaca**			13																
	Petasition paradoxi (PP)																			
	Silene quadrifida**	17	30		9		6		17			4	44	15					13	67
	Adenostyles glabra			6	18	5	6		6			8	13	8						
	Polystichum lonchitis							13	11			8								
	Rumex scutatus			25										8						
	Aconitum angustifolium*												13							
	Athamanta cretensis												6							
	Cystopteris montana											8								
	Dryopteris villarii											4								
	Gypsophila repens												6							
	Thlaspietalia rotundifolii (TR_8)																			
	Achillea atrata**	50	90	19	9	9	65	100	94				6	15	78	22		40	38	67
	Taraxacum alpinum agg.	17	40	31			18	88	83	100	75		6	23	11	28	57		25	78
	Moehringia ciliata	83	70	88	36	45	82	88	83	33	42		6	15	11	17				
	Poa minor			75		18	53		11						11	17	43			11
	Sedum atratum ssp. atratum					9	12	25	17				6		11			20		
	Cerastium carinthiacum ssp. carinthiacum*					9										11	43			
	Doronicum grandiflorum								17					8						
	Trisetum argenteum												6							
	Androsacetalia alpinae (AA)																			
	Veronica alpina		50		9	23	24	75	83	100	75				11	17		100	75	44
	Gentiana bavarica*						6				50					39		60		
	Oxyria digyna				36			13												
	Trifolium pallescens												94						13	
	Epilobium anagallidifolium										8									
	Geum reptans															6				
	Gymnocarpium dryopteris											33								
	Saxifraga seguieri*															6				
	Drabetalia hoppeanae (DH)																			
	Doronicum glaciale ssp. glaciale*			25	18								6	15		22				
	Sesleria ovata*					18	35									17				
	Thlaspietea rotundifolii (TR_1)																			
	Campanula cochleariifolia	33	60	6	27	5		25	50			8	25	31	11	22	29		13	
	Minuartia sedoides			6			6		28		8		44	15		17	14		100	
	Armeria alpina					5	24	13	22				13	8		33	14			
	Biscutella laevigata ssp. laevigata						12		17		8			8	22	17			13	
	Leontodon hispidus								6				25	8		17		20		
	Linaria alpina ssp. alpina					5		13	28											

	Saxifraga oppositifolia ssp. oppositifolia			13				25								6				
	Rhodiola rosea												6	15						
	Salicetea herbaceae (SH)																			
	Sagina saginoides					5	24	38	11	100	58				11	17			50	56
	Alchemilla fissa										50			15	11	17		6		56
	Salix herbacea									100	67						14	80		
	Sibbaldia procumbens							13									14	20		33
	Gnaphalium supinum							13											13	22
	Cerastium cerastoides									100	8									
	Soldanella pusilla															11			13	
	Asplenietea trichomanis (AT)																			
dAC_2	Silene pusilla			6	9	45	24					100				11				
dAC_3	Arabis bellidifolia ssp. stellulata	17	10	38	18	5	59		6		50				44	22			13	
dAC_3	Valeriana elongata**	50	80	31	9	9	18		11						11	17				
dAC_3	Cystopteris regia	33	40		27	14			33			13		8						
	Phyteuma sieberi*		10		9				11				19	23	33		14		25	
	Saxifraga paniculata				9		12	13	6				6	8		6				
	Paederota lutea			6					17				13	15	11					
	Asplenium viride			6								50	19	15						
	Cystopteris fragilis											46	6	8			29			
	Saxifraga crustata				9								38	8			14			
	Cerastium subtriflorum**								6				38	8						
	Valeriana saxatilis				18								6		11					
	Petrocallis pyrenaica														11				13	
	Primula clusiana*						6									6				
	Elyno-Seslerietea (ES)																			
dAC_2	Aster bellidiastrum	33	40	6	18	9	6	25	67	33	50	21	81	69	78	67	43		75	33
dAC_2	Silene acaulis				9	14	41	75	39		58		50	15	44	78	86	80	100	
dSS	Carex firma			6		5	47	50	33		33	4	38	31	78	61	14		38	
dSS	Campanula scheuchzeri					5	12		39		58	8	56	8	11	11		100	100	67
dSS	Homogyne discolor		30				6	13	11		25		31	31	89	56	14		100	78
dSS	Euphrasia salisburgensis					5		25	17				75	23	22	6		20	50	78
dSS	Bartsia alpina		20	6					17			4	13		67	44	29	40		
dSS	Carex sempervirens						6				8		88	4	11	56	57	80	38	
dSS	Dryas octopetala					5			6			4	6	8	22	39	14		25	
dSS	Potentilla crantzii								11			4	63	23	11	17	43		63	
dSS	Ranunculus carinthiacus											38	38		33	11	14		38	67
dSS	Homogyne alpina												19	15		17	29	100		
dSS	Salix serpillifolia												13		22			40		
dSS	Geranium argenteum												100	23						
	Poa alpina	50	100	38	100	73	71	100	100		83	42	69	54	78	72	57	20	100	89
	Myosotis alpestris		50		45	5	18	50	78		58	8	56	15	33	61	86	80	38	
	Carex ferruginea ssp. ferruginea						6		33		17	13	6		22	17		100	25	11
	Galium anisophyllum		10				6		56		8	29		77	56	6			38	78
	Juncus monanthos				18		6				8		88	23	33	17	14		13	
	Sesleria caerulea			6	9		6		11				38		78	44		100	63	
	Cerastium carinthiacum ssp. austroalpinum*	33	50	6	27			50	89				6	4						
	Gentiana pumila*						12	13	17					8	67	17			100	33
	Pedicularis verticillata						12		11				69	8	11	6		20	13	
	Festuca quadriflora			6	9	5	24									44		40	38	
	Arabis vochinensis							38	94					15	33				63	11
	Gentiana anisodonta							13					75	15	11				38	56
	Gentiana verna ssp. verna								6				25		22	28	14		38	
	Pedicularis rostratocapitata						6		17				6	31	11	17				
	Ranunculus montanus					5			11		50					44	43	100		
	Salix alpina			13					17				19	31		17	14			
	Achillea clavenae								17				63	24		17	14			
	Agrostis alpina								6		50			8		17			88	
	Festuca norica*	50	50	13	9															44

	Saxifraga caesia			13							8				11	6	29			
	Thymus praecox ssp. polytrichus								22				38	15		6				33
	Crepis aurea								22							6			38	78
	Draba aizoides ssp. aizoides				10			25			17							40		
	Erigeron glabratus											4	63	8		6				
	Gentiana clusii												25		11	6			38	
	Ligusticum mutellina						12				75					11		100		
	Anthyllis vulneraria ssp. alpestris										8		13		22					
	Astrantia bavarica**								11				31		11					
	Carex ornithopoda												19	8					13	
	Cerastium arvense ssp. strictum								6				13			6				
	Elyna myosuroides										8					11			25	
	Festuca violacea agg.											67			22			100		
	Gentiana orbicularis										50			8		17				
	Gentiana terglouensis*				9			25	17											
	Helianthemum alpestre												75	8					13	
	Hieracium bifidum											8		8			14			
	Hieracium villosum												56	8		6				
	Phyteuma orbiculare											13	6			6				
	Ranunculus hybridus								6					8	11					
	Sesleria sphaerocephala*			19				13											13	
	Juncetea trifidi (JT)																			
	Potentilla aurea															33	14	80	13	78
	Euphrasia minima										42		6			6	29			
	Luzula spicata ssp. spicata														11	11		20	38	
	Agrostis rupestris													8	11				13	
	Botrychium lunaria																14		13	
	Primula minima										8					28				
	Veronica bellidioides															6	14			
	Nardetea strictae (N)																			
	Coeloglossum viride										8		6	8		11				
	Luzula multiflora ssp. multiflora												6	8						
	Nardus stricta																14			22
	Loiseleurio-Vaccinietea (LV)																			
	Rhodothamnus chamaecistus**												25	8		6				
	Vaccinium gaultherioides												13			6			38	
	Juniperus communis ssp. alpina											8					14			
	Montio-Cardaminetea (MC)																			
dAC_2	Saxifraga aizoides	67	40	19	55	9	12		22		17		19	23	44	17	14		13	
dAC_3	Saxifraga stellaris			31	9	91	88	75	44	100	8			8		11				
	Scheuchzerio-Caricetea fuscae (SC)																			
	Selaginella selaginoides										33		56	8	67	50		80	63	67
	Carex capillaris										8	71	19	15	33	11			63	
	Parnassia palustris											67	88	46	11		14		13	
	Pinguicula alpina											13			22	17				
	Tofieldia calyculata													15	11	11				
	Molinio-Arrhenatheretea (M-Ar)																			
	Lotus corniculatus								6		8		31			6	29			
	Anthoxanthum odoratum												69	8		17				
	Trifolium pratense ssp. pratense								6				38			6				
	Trifolium repens ssp. repens											4		8						
	Trollius europaeus											4				11				
	Mulgedio-Aconitetea (MA)																			
dAC_2	Viola biflora	17	60		27	9			44		8	88	13	38			43		38	78
	Salix waldsteiniana											8	6	23		22	14			
	Veratrum album ssp. lobelianum								22				19	15		6				
	Aconitum lycoctonum ssp. neapolitanum								11			4	6							
	Adenostyles alliariae								6			29								
	Geranium sylvaticum								6			4								
	Salix appendiculata											71		8						

	Saxifraga rotundifolia L.		20								4								
	Erico-Pinetea (EP)																		
	Rhododendron hirsutum**										38	19	8			14			
	Pinus mugo ssp. mugo										8		8						
	Rubus saxatilis										42		8						
	Querco-Fagetea (QF)																		
	Luzula sylvatica							6			8				6	14			
	Daphne mezereum							6				6	8						
	Solidago virgaurea (incl. minuta)										4	6							
	Vaccinio-Piceetea (VP)																		
	Huperzia selago										21	6	8		6				
	Vaccinium vitis-idaea										71	13	15		6				
	Picea abies			6							58								
	Other species																		
	Polygonum viviparum		90	31	18	23	29	50	56		83	63	88	85	89	94	86	100	100	78

RESULTS AND DISCUSSION

An extensive analytical table was provided and analyses were performed applying hierarchical classification methods. Two distinct groups of relevés were recognised in the cluster analysis: stands from *Arabidion* s. lat. and *Salicion* s. lat. (Fig. 4). Within the "*Arabidion*" group, seven distinct clusters were recognised (Fig. 2): A – *Saxifragetum hohenwartii (Thlaspion, Thlaspietalia)* from the Karavanke Mts. (Tab. 1: columns 1, 2), B – *Ranunculo traunfellneri-Festucetum nitidae* from the Julian Alps (7, 8), C – *Poo-Cerastietum (Salicetea herbaceae*; 9) and *Salici herbaceae-Arabidetum caeruleae (Salici-Arabidion*; 10) from the Dolomites of Lienz, D – *Saxifragetum stellaro-sedoidis* var. geogr. *Achillea oxyloba* (3) from the Dolomites of Lienz, E –from the Julian Alps (var. geogr. *Ranunculus traunfellneri*; 4), F – from Hochschwab and Gesäuseberge (5), and G from the Hochschwab only (F-G var. geogr. *Campanula pulla*; 6).

The "*Salicion*" group consisted of nine clusters (Fig. 3): A – *Drepanoclado-Heliospermetum* from the Liburnian Karst, B – *Salici retusae-Geranietum argentei* from the Julian Alps (12), C – *Homogyno discoloris-Salicetum retusae* from the Krn Mts. (Julian Alps) and Carnic Alps (13), and D – from the Karavanke Mts. and the Kamnik Alps (14), E – *Salicetum retuso-reticulatae* from the Dolomites of Lienz and Carnic Alps (15), F – from the Monte Baldo and Dolomites of Belluno (16) and G – from Bernina (Unter-Engadin, above Val Cluoza; 17), H – *Potentillo brauneanae-Homogynetum discoloris* from the Julian Alps (18) and I – from the Karavanke Mts. (19).

Stands of *Drepanoclado-Heliospermetum* were grouped within the "*Salicion*" cluster, but several floristical, phytogeographical as well as ecological distinctions were recognised. Due to the lower altitude, such stands were inhabited by many forest *(Querco-Fagetea, Vaccinio-Piceetea, Erico-Pinetea)* and tall-herb *(Mulgedio-Aconitetea)* species (Tabs. 1–4). The presence of Illyrian species in stands, such as *Gentiana liburnica, Polygala croatica* and *Thymus balcanus* (Tab. 1) as well as *Arabis scopoliana, Scabiosa silenifolia, Carex kitaibeliana* etc. (*Seslerion juncifoliae, Seslerietalia juncifoliae, Elyno-Seslerietea*) were of phytogeographical importance (Surina & Vreš, 2004). In comparison to other syntaxa, Alpine geoelements in the broadest sense occurred more sporadically, while Eurosiberian and Eurosiberian/N-American geoelements prevailed (Tab. 2).

Secondly, a synoptic table (Tab. 1) was provided with the aid of cluster analysis (Fig. 4) and on the basis of previous results obtained within both groups of relevés.

Distinction between the *Arabidion* and the *Soldanello-Salicion* were evident and delimitation of *Arabidion* according to Englisch (1999) into at least two alliances was not questionable (Tabs. 1–4). Scree stability, aspect and talus slope may be the three most important environmental factors that determine the floristic composition and differentiation of the alliances: *Arabidion* prefers shady and slightly less stabilised scree with no or very little accumulation of soils and perhaps steeper slopes in comparison to the *Soldanello-Salicion*. The coverage indices and number of species of the *Thlaspion* and the *Androsacetalia alpinae*, which prefer less stabilised screes, were also much higher. The *Poo-Cerastietum* and *Salici-Arabidetum* were grouped together in the cluster analysis, but within the "*Arabidion*" cluster (Fig. 2: cluster C; Fig. 4: clusters 9, 10). The later syntaxon was placed into the *Salici-Arabidion* (Englisch, 1999), which was separated from *Salicion herbaceae* due to floristical and ecological differences derived from the fact that the newly proposed alliance embraces the snow-bed vegetation on humus rich calcareous screes. The number and coverage indices of acidophilous and hygrophilous species of *Salicetea herbaceae, Androsacetalia alpinae, Juncetea trifidi, Nardetea, Vaccinio-Piceetea* and *Scheuchzerio-Caricetea fuscae* (Tabs. 1, 3, 4) proved the unique syntaxonomic position of *Salici-Arabidetum* (between *Salicion herbaceae* and *Arabidion caeruleae*) and the aforementioned classification of syntaxa.

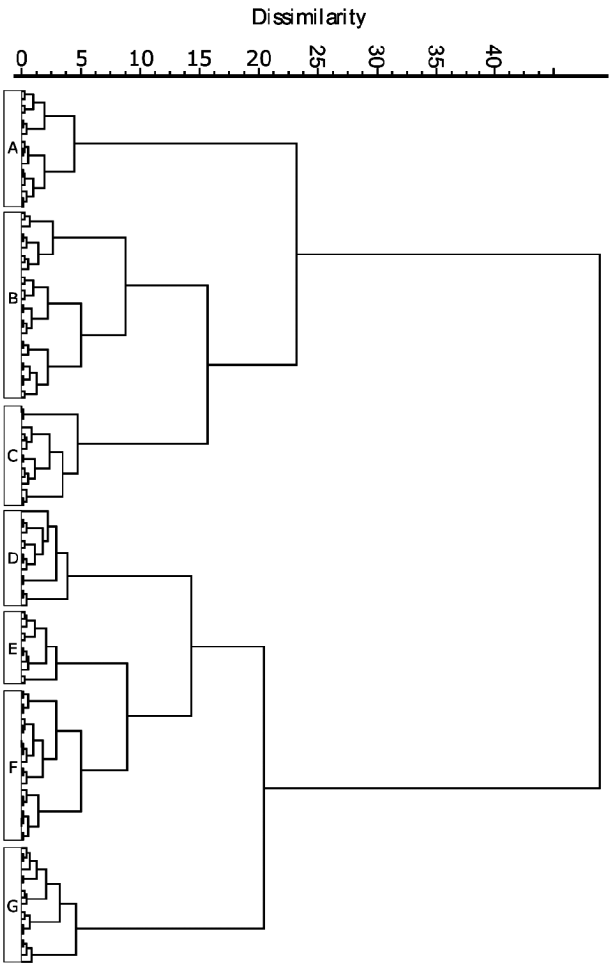

Fig. 2: Dendrogram based on species frequency in the syntaxa of *Arabidetalia caeruleae* ***s. lat. in the South-eastern and North-eastern Calcareous Alps. A –*** *Saxifragetum hohenwartii****; B –*** *Ranunculo traunfellneri-Festucetum nitidae****; C –*** *Poo supinae-Cerastietum cerastoidis* ***&*** *Salici herbaceae-Arabidetum caeruleae****; D –*** *Saxifragetum stellaro-sedoidis* ***var. geogr.*** *Achillea oxyloba****; E –*** ***var. geogr.*** *Ranunculus traunfellneri****; F–G –*** ***var. geogr.*** *Campanula pulla****.***

Sl. 2: Dendrogram, izdelan na osnovi pogostosti vrst v sintaksonu *Arabidetalia caeruleae* ***s. lat. v jugovzhodnih in severovzhodnih Apneniških Alpah. A –*** *Saxifragetum hohenwartii****; B –*** *Ranunculo traunfellneri-Festucetum nitidae****; C –*** *Poo supinae-Cerastietum cerastoidis* ***&*** *Salici herbaceae-Arabidetum caeruleae****; D –*** *Saxifragetum stellaro-sedoidis* ***var. geogr.*** *Achillea oxyloba****; E –*** ***var. geogr.*** *Ranunculus traunfellneri****; F–G –*** ***var. geogr.*** *Campanula pulla****.***

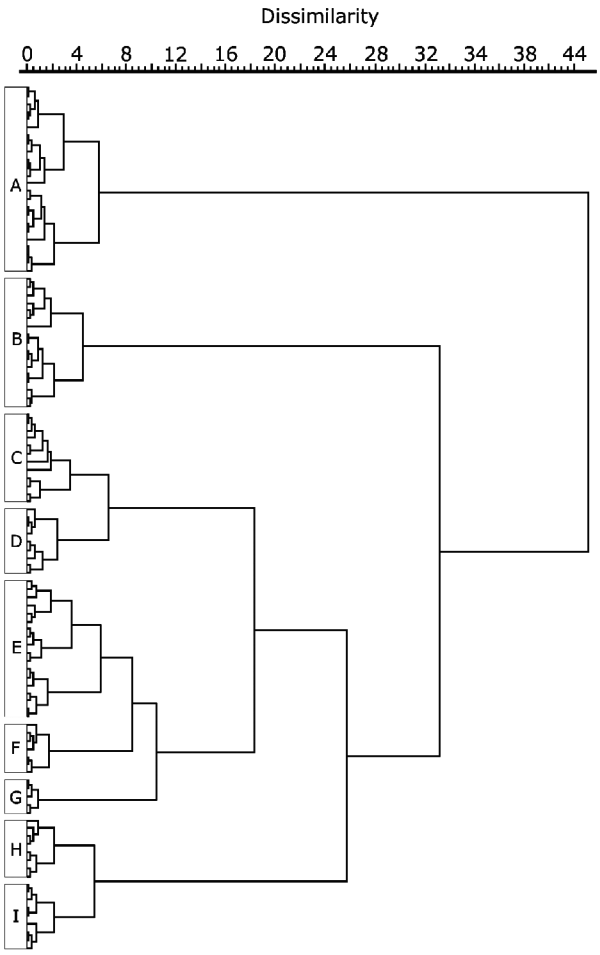

Fig. 3: Dendrogram based on species frequency in the syntaxa of *Soldanello alpinae-Salicion retusae* ***s. lat. in the South-eastern and North-eastern Calcareous Alps. A –*** *Drepanoclado uncinati-Heliospermetum pusilli****; B –*** *Salici retusae-Geranietum argentei****; C, D –*** *Homogyno discoloris-Salicetum retusae****; E–G –*** *Salicetum retuso-reticulatae****; H–I –*** *Potentillo brauneanae-Homogynetum discoloris****.***

Sl. 3: Dendrogram, izdelan na osnovi pogostosti vrst v sintaksonu *Soldanello alpinae-Salicion retusae* ***s. lat. v jugovzhodnih in severovzhodnih Apneniških Alpah. A –*** *Drepanoclado uncinati-Heliospermetum pusilli****; B –*** *Salici retusae-Geranietum argentei****; C, D –*** *Homogyno discoloris-Salicetum retusae****; E–G –*** *Salicetum retuso-reticulatae****; H–I –*** *Potentillo brauneanae-Homogynetum discoloris****.***

Tab. 2: Chorological groups (geoelements) of syntaxa of *Arabidetalia caeruleae* ***in the SE Alps (* endemic, ** subendemic species).***
Tab. 2: Horološke skupine (geoelementi) sintaksonov *Arabidetalia caeruleae* ***v JV Alpah (* endemične, ** subendemične vrste).***

Geoelement / No. of spec.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
S-Eur.-Mont.	3	8	12	11	16	18	14	31	3	26	23	30	31	27	27	18	45	23	18
Arct./Alp.	3	6	6	8	9	9	19	12	5	12	7	13	12	13	14	6	21	10	10
SE-Europ.-Mont.	1	1	4	3	3	5	4	6	2	5	8	10	8	7	6	2	9	3	3
E-Alp.**	4	4	5	4	2	4	3	9		1	2	9	6	6	4	2	6	2	1
Eurosib./N-Am.	1	1	2	1	1	1	2	2		5	13	8	8	4	4	2	6	3	2
E-Alp.*	4	6	6	5	7	10	5	6	1	1		7	6	5	3	2	14	4	
Euroasiat.	1	1	1	1	1	1	1	1	2	1	2	1	2	1	2		6		1
E-Alp./Illyr.		1	1	2		1	4	7		1	3	7	7	4	2	2	4	5	
Europ.	1	1	2	2	1	2		4			6	8	5	2	2		6	2	2
Alp.*	1	1	2	2	2		1	3		3		1		1	1		3	1	1
E-Alp./Apen.			1	2	1	1	1	1	1	1		1	1	1	1		1	1	
Europ-/N-Am.				2		2	1	1		1		3	3	1	1		2	1	
Alp.					1	2	2	3		3		1			2		3	1	1
Europ./Mont.			1			1		3		1	1	3	1		3		1	1	
Other							1	4			5	2	3		3		3	1	1
NE-Alp./Illyr.**	1			1		1		1			2	1	1		1	1			
N-Europ.-Alp.				1		1					1	1	1	1			1	1	1
Eurosib.								4			10	3	4	1		1	3	1	
Alp./Apen.						1	1	1	1	1		1	1				1		
Cosmop.											2	1	1		1	1		2	
E-Alp/Carpat			1					2				1	1				1	1	
Alp./Illyr.			1				1					1		1					1
Eurasiat./Afr.								1		1		1					1	1	
Europ./W-Asiat.								1			2	2	2						
Euroasiat./N-Am.										1	3	1					1		
Eurasiat./Am.											1	1	1				1		
S-Europ.					1		1	1									1		
W-Alp.*											1			1					1

Accumulation of soil and formation of tiny horizons, slow decomposition of dead plant material, and subsequent acidification of soils are well suited to species of the *Juncetea trifidi, Nardetea, Loiseleurio-Vaccinietea, Scheuchzerio-Caricetea fuscae*, and *Vaccinio-Piceetea* (Tabs. 3, 4), which were significantly more abundant and achieved higher coverage indices in syntaxa of the *Soldanello-Salicion*. Associations of *Soldanello-Salicion*, restricted mainly to shallow depressions with long lasting snow, were less frigiphilous (Braun-Blanquet, 1926; Englisch *et al.*, 1993) and were species richer, which was mainly due to the occurrence of the *Elyno-Seslerietea* species (Fig. 5). They also achieved relatively high coverage indices. The high share of species of subalpine and alpine calcareous grasslands in the *Salicetum retuso-reticulatae* was already mentioned by Pignatti & Pignatti (1983), while the *Diantho alpinae-Salicetum retusae,* the *Homogyno-Salicetum* and the *Salici-Geranietum* are transitional to the *Elyno-Seslerietea* (mainly the *Caricion firmae*; see Englisch, 1999; Surina, 2004c) and play an important role in the subsequent succession of calcareous scree vegetation towards subalpine and alpine calcareous grasslands.

Our study revealed phytogeographical differentiation of stands of *Saxifragetum stellaro-sedoidis* (Englisch *et al.*, 1993; Englisch, 1999) and several geographical variants or races based on the floristical peculiarities of the area could be distinguished (Tab. 1, Figs. 2, 4).

This was mainly owing to disjunctions of the distribution area of closely related endemic taxa (Tabs. 1, 2), which vicariate in a SE-NE direction (NE-Calcareous Alps – SE-Calcareous Alps), *e.g. Saxifraga sedoides – S. hohenwartii*, *Soldanella austriaca – S. minima*, *Ranunculus alpestris – R. traunfellneri*, *Cerastium carinthiacum* subsp. *carinthiacum – C. c.* subsp. *austroalpinum* etc. (see Hörandl, 1993). As geographical differential species we chose *Achillea clusiana, Soldanella austriaca* and *Campanula pulla* for the NE Calcareous Alps, *Ranuncu-*

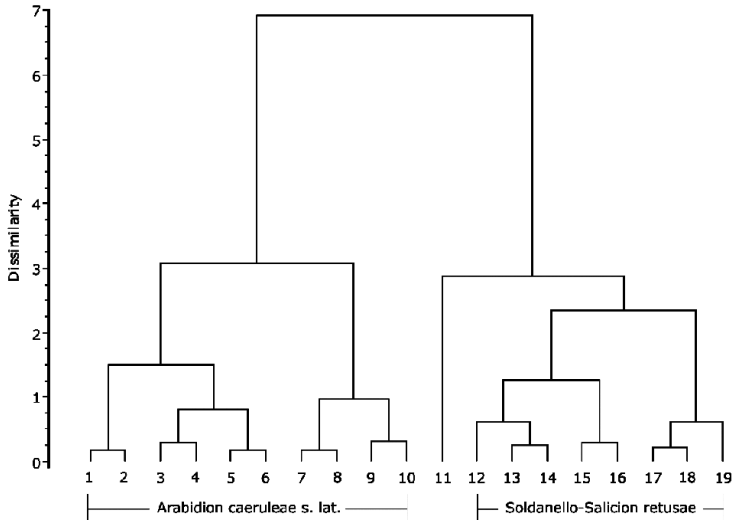

Fig. 4: Dendrogram based on species frequency in the syntaxa of** Arabidetalia caeruleae **s. lat. in the South-eastern and North-eastern Calcareous Alps. 1, 2 –** Saxifragetum hohenwartii**; 3 –** Saxifragetum stellaro-sedoidis **var. geogr.** Achillea oxyloba**; 4 –** Saxifragetum stellaro-sedoidis **var. geogr.** Ranunculus traunfellneri**; 5, 6 –** Saxifragetum stellaro-sedoidis **var. geogr.** Campanula pulla**; 7, 8 –** Ranunculo traunfellneri-Festucetum nitidae**; 9 –** Poo supinae-Cerastietum cerastoidis**; 10 –** Salici herbaceae-Arabidetum coeruleae**; 11 –** Drepanoclado uncinati-Heliospermetum pusilli**; 12 –** Salici retusae-Geranietum argentei**; 13, 14 –** Homogyno discoloris-Salicetum retusae**; 15–17 –** Salicetum retuso-reticulatae**; 18, 19 –** Potentillo brauneanae-Homogynetum discoloris **(numbers correspond with Table 1).

Sl. 4: Dendrogram, izdelan na osnovi pogostosti vrst v sintaksonu Arabidetalia caerule s. lat. v jugovzhodnih in severovzhodnih Apneniških Alpah. 1, 2 –** Saxifragetum hohenwartii**; 3 –** Saxifragetum stellaro-sedoidis **var. geogr.** Achillea oxyloba**; 4 –** Saxifragetum stellaro-sedoidis **var. geogr.** Ranunculus traunfellneri**; 5, 6 –** Saxifragetum stellaro-sedoidis **var. geogr.** Campanula pulla**; 7, 8 –** Ranunculo traunfellneri-Festucetum nitidae**; 9 –** Poo supinae-Cerastietum cerastoidis**; 10 –** Salici herbaceae-Arabidetum coeruleae**; 11 –** Drepanoclado uncinati-Heliospermetum pusilli**; 12 –** Salici retusae-Geranietum argentei**; 13, 14 –** Homogyno discoloris-Salicetum retusae**; 15–17 –** Salicetum retuso-reticulatae**; 18, 19 –** Potentillo brauneanae-Homogynetum discoloris **(številke se ujemajo s tistimi v Tabeli 1).

lus traunfellneri for the SE Calcareous Alps and *Achillea oxyloba* for Mt. Baldo, the Dolomites of Lienz and Belluno, and the Carnic Alps. It has recently been established that *Saxifraga sedoides* from the Dolomites of Lienz was wrongly identified as *S. hohenwartii* by Wikus (Wikus, 1959: Tab. 7), since the species is restricted to the Karavanke Mts. and the Kamnik Alps. We thus treated selective stands (Dirnböck *et al.*, 1999: Tab. 12, rel. 8) as the *Saxifragetum stellaro-sedoidis* var. geogr. *Achillea oxyloba*.

Lectotypes:

- *Saxifragetum stellaro-sedoidis* Englisch 1999 var. geogr. *Campanula pulla* var. geogr. nova: Dirnböck *et al.* (1999: Tab. 12, rel. 8) – Hochschwab, *lectotypus hoc loco*.
- *Saxifragetum stellaro-sedoidis* Englisch 1999 var. geogr. *Ranunculus traunfellneri* var. geogr. nova: Surina (2004c: Tab. 1, rel. 2) – Julian Alps, *lectotypus hoc loco*.
- *Saxifragetum stellaro-sedoidis* Englisch 1999 var. geogr. *Achillea oxyloba* var. geogr. nova: Wikus (1959: Tab. 7, rel. 5) – Dolomites of Lienz, *lectotypus hoc loco*.

Stands of the *Saxifragetum hohenwartii*, in line with recent syntaxonomical literature on calcareous scree vegetation (Englisch *et al.*, 1993; Englisch, 1999), were placed into *Thlaspion rotundifolii* as earlier proposed by Wikus (1959), Zollitsch (1967) and Wraber (1970). Although stands with predominating *Saxifraga hohenwartii* were transitional between the *Thlaspion* and the *Arabidion*, our views on the syntaxonomy of the *Saxifragetum hohenwartii* was in agreement with the author of the unit (Aichinger, 1933), who placed this association into the *Arabidion*. We considered those associations to be a phytogeographical vicariant (in the Karavanke Mts. and Kamnik Alps) to the *Saxifragetum stellaro-sedoidis* s. lat.

Within the *Soldanello-Salicion* (Fig. 3), four associations were clearly identified, such as the *Salici-Geranietum*, the *Homogyno-Salicetum*, the *Salicetum retuso-reticulatae*, and the *Potentillo-Homogynetum*. Floristical distinctions between the *Homogyno-Salicetum* and the *Salicetum retuso-reticulatae* were not only due to the presence or absence of *Salix reticulata*, *Carex ferruginea* and *Homogyne discolor* (*e.g.* Englisch, 1999), but also owing to the significantly higher coverage indices and number of acidophilous species of the *Androsacetalia al-*

pinae, the *Salicetea herbaceae* and the *Juncetea trifidi* (Tabs. 1, 3, 4). Stands with predominating *Salix retusa* showed certain phytogeographical and ecological differentiation. Several vicariant syntaxa were therefore described: the *Homogyno-Salicetum* and the *Salici-Geranietum* for the SE Calcareous Alps, and the *Diantho-Salicetum* and the *Selaginello selaginoidis-Salicetum reticulatae* for the NE Calcareous Alps. In contrast to stands of the *Homogyno-Salicetum* and the *Salicetum retuso-reticulatae*, stands of the *Salici-Geranietum* and the *Diantho-Salicetum* were transitional to stands of alpine calcareous grasslands (the *Caricion firmae*), and stands of *Potentillo-Homogynetum* transitional to stands of *Loiseleurio-Vaccinietea*. Several succession stages of *Salicetum retusae* s. lat. were observed: in the SE Calcareous Alps towards stands of *Gentiano terglouensis-Caricetum firmae* and *Dryadetum octopetalae* s. lat., and in the NE Calcareous Alps towards stands of *Caricetum firmae* (Wendelberger, 1971; Englisch *et al.*, 1993; Englisch, 1999; Surina, 2004b). For a more detailed description of the ecology, chorology and syntaxonomy of snow-bed vegetation, see previously cited references.

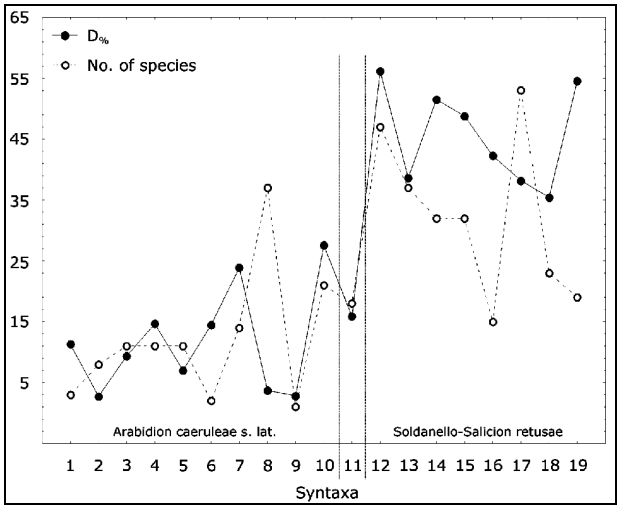

Fig. 5: Coverage index ($D_{‰}$) and number of alpine and subalpine calcareous grasslands species *(Elyno-Seslerietea)* ***in syntaxa of*** *Arabidetalia caeruleae* ***in SE Alps.***
Sl. 5: Indeks pokrivnosti ($D_{‰}$) ter število alpinskih in subalpinskih apneniških traviščnih vrst (Elyno-Seslerietea) ***v sintaksonih*** *Arabidetalia caeruleae* ***v JV Alpah.***

Tab. 3: Phytosociological groups of syntaxa of *Arabidetalia caeruleae* ***in the SE Alps.***
Tab. 3: Fitosociološke skupine sintaksonov *Arabidetalia caeruleae* ***v JV Alpah.***

Syntaxa / No. of spec.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Me**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**Me**
Arabidion caeruleae	5	6	6	7	6	8	7	9	3	7	**6.5**		3	5	8	7	3	9	3	3	**4.0**
Soldanello-Salicion		1	1		1	2	1	2		3	**1.0**	1	2	2	3	2	2	3	3	3	**2.5**
Arabidetalia caeruleae	1	2	3	6	3	5	5	6	1	4	**3.5**	2	4	6	5	4	2	7	3	3	**4.0**
Thlaspion rotundifolii			4	1	3		4	2		1	**1.0**							1			**0.0**
Petasition paradoxi	1	1	2	2	1	2	1	3			**1.0**	5	5	3		1	1				**0.5**
Thlaspietalia rotundifolii	3	3	6	2	6	6	4	6	3	3	**3.5**		6	5	5	2	3	6	4	2	**4.5**
Androsacetalia alpinae		1		2	1	2	2	1	1	3	**1.0**	1	1		1	2	1	4		2	**1.0**
Drabetalia hoppeanae			2	1	1	2		1		1	**1.0**		2	2		1		3	1		**1.0**
Thlaspietea rotundifolii	2	2	3	2	4	3	5	6		1	**2.5**	2	4	6	3	2		5	2	1	**2.5**
Salicetea herbaceae					1	1	3	1	3	4	**1.0**			1	2	3	4	4	2	3	**2.5**
Asplenietea trichomanis	2	3	4	7	3	5	2	8	1	1	**3.0**	6	12	8	5	3		4	3		**3.5**
Elyno-Seslerietea	3	8	11	11	11	2	14	37	1	21	**11.0**	18	47	37	32	32	15	53	23	19	**32.0**
Vaccinio-Piceetea			1					1		1	**0.0**	1	3	4				3	1	1	**1.0**
Scheuczerio-Caricetea fuscae										3	**0.0**	3	5	4	5	3	1	6	1	1	**3.5**
Juncetea trifidi										2	**0.0**			1	2	6	1	11	4	2	**2.0**
Nardetea										1	**0.0**		2	4			1	1	1		**1.0**
Loiseleurio-Vaccinietea											**0.0**	1	3	1		1		3	1		**1.0**
Molinio-Arrhenatheretea	1	1	1	1	1	1	1	4	1	2	**1.0**	5	7	3	1	1	2	6	2	1	**2.0**
Montio-Cardaminetea	1	1	2	2	2	2	1	2	1	2	**2.0**	1	1	2	1	1		2	1		**1.0**
Mulgedio-Aconitetea	1	2		1	1			8		1	**1.0**	7	4	4	1	1	1	2	5		**1.5**
Erico-Pinetea											**0.0**	6	1	3	2				1		**0.5**
Querco-Fagetea								3			**0.0**	20	3	2				2	1		**0.5**
Artemisietea vulgaris							1	1		1	**0.0**					1		1			**0.0**
Festuco-Brometea						1					**0.0**		1	1		1					**0.0**
Trifolio-Geranietea											**0.0**		1					1			**0.0**
Seslerion juncifoliae											**0.0**	3									**0.0**
Epilobietea angustifolii											**0.0**	2									**0.0**
Other species							1	4			**0.0**	5	2	3		3		3	1	1	**1.5**

CONCLUSIONS

1. Delimitation among the alliances *Arabidion, Salici-Arabidion* and *Soldanello-Salicion*, based on floristic composition and the phytogeographical peculiarities of the area as well as the specific ecology of stands, was distinct and several phytogeographical and/or ecological vicariant syntaxa were recognised. Within the *Arabidion*, three associations were recognised in the study area, such as the *Ranunculo-Festucetum* (an endemic association in the Julian Alps), the *Saxifragetum hohenwartii* (restricted to the Karavanke Mts. and the Kamnik Alps), and the *Saxifragetum stellaro-sedoidis* (distributed throughout the Eastern Alps). The latter was subdivided into three geographical variants, such as variants of *Achillea oxyloba* (western part of the SE Alps: Monte Baldo, Dolomites, Carnic Alps), of *Ranunculus traunfellneri* (mainly SE Calcareous Alps), and of *Campanula pulla* (NE Alps).

2. The *Salici-Arabidetum* was placed into the *Salici-Arabidion* and our analysis partly confirmed its unique syntaxonomic position between the *Arabidion* and the *Salicion herbaceae*. This association is distributed in the Northern, Central and Southern Alps.

3. Within the *Soldanello-Salicion*, four associations were clearly recognised, such as the *Homogyno-Salicetum*, the *Salicetum retuso-reticulatae*, the *Salici-Geranietum*, and the *Potentillo-Homogynetum*. The distribution area of the *Salicetum retuso-reticulatae* is restricted mainly to the NE, SE and Central Alps, and is replaced by the *Homogyno-Salicetum* in the SE Calcareous Alps. To date, stands of the *Salici-Geranietum* have only been documented in the Julian Alps and constitute somewhat transitional unit of the *Elyno-Seslerietea (Caricion firmae).*

4. Our study confirmed the placement of the *Drepanoclado-Heliospermetum* from the Liburnian Karst into the Dinaric alliance *Salicion retusae*. Since no synoptic treatment of Dinaric syntaxa has yet been provided, syntaxonomical and geographical delimitations of the *Soldanello-Salicion* and the *Salicion retusae* have remained unresolved. Nevertheless, stands from the Trnovski gozd plateau (NW Dinaric Mts., Slovenia) resembled those of Mt. Snežnik and are probably situated in the north-westernmost part of the distribution area of the *Salicion retusae*.

Tab. 4: Index of coverage ($D_{\%}$) of phytosociological groups of syntaxa of *Arabidetalia caeruleae* ***in the SE Alps.***
Tab. 4: Indeks pokrivnosti ($D_{\%}$) fitosocioloških skupin sintaksonov *Arabidetalia caeruleae* ***v JV Alpah.***

Syntaxa / $D_{\%}$	1	2	3	4	5	6	7	8	9	10	Me	11	12	13	14	15	16	17	18	19	Me
Arabidion caeruleae	33.78	27.59	27.69	27.56	16.93	34.45	19.28	15.66	2.00	19.17	23.42		1.57	7.94	6.70	8.33	17.76	1.29	1.36	5.59	6.14
Soldanello-Salicion		3.24	0.40		0.27	2.94	0.53	4.59		6.35	0.46	0.18	7.28	16.99	14.67	5.58	7.19	15.45	19.58	13.47	14.07
Arabidetalia caeruleae	9.00	7.29	7.38	13.35	15.49	13.95	8.43	11.54	8.18	4.47	8.71	0.67	2.21	7.96	6.64	8.00	1.26	5.96	3.28	4.46	5.21
Thlaspion rotundifolii			9.56	0.85	1.64		4.32	1.30		1.15	1.00							0.79			0
Petasition paradoxi	1.32	1.37	4.58	1.75	0.27	0.45	0.53	0.97			0.75	1.78	2.63	1.37		0.28	2.72				0.14
Thlaspietalia rotundifolii	12.58	12.13	22.80	3.50	8.98	14.28	18.52	11.74	13.64	9.23	12.36		1.76	3.42	4.39	1.76	6.98	4.98	1.36	2.23	2.82
Drabetalia hoppeanae			2.19	2.56	1.92	2.95		0.72		0.43	0.58		1.58	1.54		2.41		1.66	0.60		1.07
Androsacetalia alpinae		2.29		3.50	1.64	1.25	4.52	2.59	1.82	5.19	2.05	0.98	3.30		0.35	2.26	1.88	1.98		5.39	1.93
Thlaspietea rotundifolii	9.93	8.89	5.78	8.87	9.64	3.24	5.68	3.81		0.29	5.73	1.36	1.87	3.43	1.76	0.56		3.65	1.79	0.67	1.77
Salicetea herbaceae					0.42	1.13	3.54	0.36	28.75	1.43	0.39			0.75	0.73	2.68	8.37	2.27	1.19	5.59	1.73
Asplenietea trichomanis	9.93	8.47	3.79	6.68	5.48	4.38	5.30	2.59	6.36	4.32	5.39	7.67	4.62	4.29	3.17	1.13		1.34	2.39		1.86
Elyno-Seslerietea	11.29	2.73	9.37	14.65	6.98	14.49	23.88	3.72	2.82	27.55	10.33	15.88	56.13	38.66	51.54	48.78	42.26	38.19	35.44	54.55	45.52
Vaccinio-Piceetea			0.60					0.22		0.29	0	9.50	1.15	3.13				0.95	1.19	3.37	1.05
Scheuczerio-Caricetea fuscae										5.98	0	5.42	5.74	3.59	5.32	3.53	2.72	2.92	0.60	2.69	3.22
Juncetea trifidi										1.87	0			0.38	0.73	2.82	3.35	4.82	2.99	3.37	2.91
Nardetea										0.29	0		0.29	1.58			0.84	0.32	0.60		0.30
Loiseleurio-Vaccinietea											0	0.24	1.81	0.38		0.99		0.64	0.60		0.49
Molinio-Arrhenatheretea	3.97	5.26	2.59	8.87	6.16	3.29	6.32	4.64	13.51	3.75	4.95	3.73	7.00	3.52	3.34	4.66	5.23	3.78	4.18	0.67	3.98
Montio-Cardaminetea	7.95	2.59	4.38	7.12	8.43	5.90	3.77	1.80	7.27	0.86	5.14	3.47	0.43	1.30	1.58	0.28		0.79	0.60		0.52
Mulgedio-Aconitetea	1.32	3.89		2.85	0.55			3.88		0.72	0.64	9.15	1.86	4.97	1.23	1.41	3.14	1.29	4.18		1.63
Erico-Pinetea											0	5.22	0.52	1.22	1.23				0.60		0.26
Querco-Fagetea								0.54			0	7.92	0.87	0.75				0.39	1.00		0.20
Festuco-Brometea						0.23					0		0.29	0.38		0.42					0
Trifolio-Geranietea											0		0.43					0.16			0
Artemisietea vulgaris							1.53	4.89		0.43	0					0.28		0.32			0
Seslerion juncifoliae											0	0.36									0
Epilobietea angustifolii											0	0.82									0
Other species							0.53	1.44			0	13.37	3.12	1.13		5.96		0.47	1.19	0.67	0.90

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FITOGEOGRAFSKA IN SINTAKSONOMSKA ANALIZA VEGETACIJE SNEŽNIH DOLINIC NA KARBONATNI PODLAGI V JUGOVZHODNIH ALPAH: NUMERIČNI PRISTOP

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POVZETEK

*Avtor v prispevku s pomočjo klastrske analize in opirajoč se na fitogeografske posebnosti območja podaja pregled vegetacije snežnih dolinic na karbonatni podlagi v Jugovzhodnih Alpah (*Arabidetalia caeruleae, Thlaspietea rotundifolii*). Obravnava osem asociacij, ki se dobro razlikujejo ekološko in fitogeografsko, te pa združuje v tri zveze. Asociacije* Saxifragetum stellaro-sedoidis, Saxifragetum hohenwartii *in* Ranunculo traunfellneri-Festucetum nitidae *pripadajo zvezi* Arabidion caeruleae*, asociacija* Salici herbaceae-Arabidetum caeruleae*, ki je v sintaksonomskem oziroma ekološkem oziru sorodna s sintaksoni snežnih dolinic na silikatni podlagi iz razreda* Salicetea herbaceae*, pa zvezi* Salici herbaceae-Arabidion caeruleae*. Asociacija* Saxifragetum stellaro-sedoidis *se fitogeografsko dobro diferencira v tri nove geografske variante, in sicer* Achillea oxyloba *v Lienških Dolomitih,* Ranunculus traunfellneri *v Jugovzhodnih Apneniških Alpah ter* Campanula pulla *v Severovzhodnih Apneniških Alpah.*

Analiza je nadalje potrdila smiselnost obravnavanja sestojev, v katerih prevladujeta vrbi Salix retusa *in* S. reticulata *v okviru samostojne zveze* Soldanello alpinae-Salicion retusae*. Na območju Jugovzhodnih Alp pripadajo tej zvezi štiri asociacije:* Salicetum retuso-reticulatae, Homogyno discoloris-Salicetum retusae, Salici retusae-Geranietum argentei *in* Potentillo brauneanae-Homogynetum discoloris*. Asociacija* Drepanoclado uncinati-Heliospermetum pusilli*, ki jo poznamo z Liburnijskega krasa (severozahodni Dinaridi), se floristično, fitogeografsko in ekološko zelo dobro loči od sintaksonov vzhodno-alpske zveze* Soldanello-Salicion retusae *in jih uvrščamo v dinarsko zvezo* Salicion retusae.

Ključne besede: biogeografija, sintaksonomija, endemiti, klastrska analiza, vegetacija snežnih dolinic, *Arabidetalia caeruleae, Thlaspietea rotundifolii*

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APPENDIX

List of relevés considered in the analysis (Tab. 1)

1 – *Saxifragetum hohenwartii*, Aichinger (1933): Tab. 9, relevés 1, 4, 11, 14–16; **2** – *Saxifragetum hohenwartii*, Aichinger (1933): Tab. 9, relevé 2, 3, 5–10, 12, 13; **3** – *Saxifragetum stellaro-sedoidis* var. geogr. *Achillea oxyloba*, Wikus (1959): Tab. 7, relevé 1–12, 14 (sub nom. *Saxifragetum hohenwartii),* Englisch (1999): Tab. G, relevé 45; Hörandl (1993) in Englisch (1999): Tab. G.: 35, 36, **4** – *Saxifragetum stellaro-sedoidis* var. geogr. *Ranunculus traunfellneri*, Wraber (1972): Tab. 9, relevés 1 (sub nom. *Saxifrago sedoidi-Arabidetum caeruleae),* Surina (2004b): Tab. 9, Wikus (1959): Tab. 7, relevé 13 (sub nom. *Saxifragetum hohenwartii),* Englisch (1999): Tab. G, relevés 22, 38; **5** – *Saxifragetum stellaro-sedoidis* var. geogr. *Campanula pulla*, Dirnböck *et al.* (1999): Tab. 12, relevés 12, 19, 20, Englisch (1999): Tab. G, relevés 20, 21, 25–34, 39–42; **6** – *Saxifragetum stellaro-sedoidis* var. geogr. *Campanula pulla*, Dirnböck *et al.* (1999): Tab. 12, relevés 8-11, 13–17, Englisch (1999): Tab. G, relevé 13, 14, 15, 16, 17, 18, 19, 23; **7** – *Ranunculo traunfellneri-Festucetum nitidae*, Wraber (1972): Tab. 9, relevés 3, 4, 6-9, 11, 12 (sub nom. *Saxifrago sedoidi-Arabidetum caeruleae*); **8** – *Ranunculo traunfellneri-Festucetum nitidae*, Wraber (1972): Tab. 9, relevés 5, 10, 13 sub nom. *Saxifrago-Arabidetum*, Tab. 10 (sub nom. *Festuco violaceae-Rumicetum nivalis);* **9** – *Poo supinae-Cerastietum cerastoidis*, Wikus (1959): Tab. 10, relevés 1–3 (sub nom. *Arabidetum caeruleae poetosum supinae);* **10** – *Salici herbaceae-Arabidetum caeruleae*, Wikus (1959): Tab. 10, relevés 4–15 (sub nom. *Arabidetum caeruleae*); **11** – *Drepanoclado uncinati-Heliospermetum pusilli*, Surina & Vreš (2004): Tab. 1; **12** – *Salici retusae-Geranietum argentei*, Surina (2004c): Tab. 11; **13** – *Homogyno discoloris-Salicetum retusae*, Surina (2004c): Tab. 12, Poldini & Martini (1993): Tab. 1, relevés 1, 2, 7 (sub nom. *Salicetum retuso-reticulatae),* Aichinger (1933): Tab. 10, relevé 6; **14** – *Homogyno discoloris-Salicetum retusae*, Aichinger (1933): Tab. 10, relevés 1–5, Haderlapp (1982): Tab. 1, relevés 62–64; **15** – *Salicetum retuso-reticulatae*, Gerdol & Piccoli (1982): Tab. 4, relevé 4, Poldini & Martini (1993): Tab. 1, relevés 3–6, 8–13, Dirnböck *et al.* (1999): Tab. 12, relevés 1–7; **16** – *Salicetum retuso-reticulatae*, Gerdol & Piccoli (1982): Tab. 4, relevés 1–3, 5, Lasen (1983): relevé 19–21; **17** – *Salicetum retuso-reticulatae*, Braun-Blanquet (1926): Tab. 4. **18** – *Potentillo brauneanae-Homogynetum discoloris*, Wraber (1972): Tab. 10; **19** – *Potentillo brauneanae-Homogynetum discoloris*, Aichinger (1933): Tab. 12.

Species with lower frequencies in the Table 1 (*/** endemic and subendemic species in the SE Alps)

Artemisietea – *Cirsium spinosissimum* 25 (7), 89 (8), 8 (10), 13 (15), 11 (17); **AT** – *Campanula cespitosa*** 6 (8), *C. justiniana* 25 (11), *Moehringia muscosa* 8 (11), *Festuca stenantha* 13 (12), *Saxifraga hostii / hostii*** 19 (12), *S. squarrosa*** 19 (12), *Potentilla nitida* 13 (15); **ES** – *Anemone narcissiflora* 31 (12), 5 (15), *Arenaria ciliata* 8 (13), *Carex mucronata* 6 (2), 4 (11), *Chamorchis alpina* 8 (13), 6 (17), *Erigeron uniflorus* 8 (13), 60 (19), *Festuca brachystachys* ssp. *brachystachys*** 12 (6), 6 (17), *Festuca melanopsis** 6 (17), 43 (18), *Galium baldense** 6 (17)m 57 (18), *Gentiana nivalis* 31 (12), 31 (13), *Helianthemum nummularium* ssp. *grandiflorum* 6 (12), 6 (17), *Koeleria eriostachya* 33 (11), 50 (12), *Leontopodium alpinum* 19 (12), 29 (18), *Luzula glabrata** 6 (6), 6 (17), *Minuartia verna* ssp. *verna* 17 (8), 38 (15), *Oxytropis jacquinii* 13 (12), 13 (15), *Pedicularis rosea* ssp. *rosea*** 6 (8), 6 (17), *Pimpinella alpina* 38 (12), 8 (13), *Polygala alpestris* 8 (10), 15 (13), *Stachys alopecuros / alopecuros* 6 (8), 13 (12), *Trifolium thalii* 22 (16), 29 (18), *Androsace chamaejasme* 11 (17), *Aster alpinus* 13 (12), *Callianthemum coriandrifolium* 100 (19), *Carduus defloratus* agg. 6 (6), *Dianthus alpinus** 6 (17), *Festuca calva** 6 (13), *Gentiana froelichii* ssp. *froelichii** 11 (14), *G. liburnica** 4 (11), *Globularia nudicaulis* 4 (11), *Hedysarum hedysaroides* ssp. *hedysaroides* 6 (17), *Helictotrichon parlatorei** 13 (12), *Heracleum austriacum* ssp. *siifolium** 6 (8), *Horminum pyrenaicum* 17 (17), *Laserpitium peucedanoides* 6 (8), *Leucanthemum atratum* ssp. *atratum** 6 (17), *L. a.* ssp. *lithopolitanicum** 11 (14), *Linum alpinum* 8 (13), *Lloydia serotina* 25 (15), *Plantago atrata* ssp. *atrata* 8 (10), *Polygala croatica* 1 (11), *Pulsatilla alpina* ssp. *alpina* 6 (17), *Rhinanthus glacialis* 19 (12), *Saussurea pygmea* 6 (8), *Saxifraga exarata* ssp. *atropurpurea** 19 (12), *S. e.* ssp. *moschata* 5 (5), *Scabiosa lucida* ssp. *lucida* 6 (17), *Thymus balcanus** 8 (11), *Viola calcarata* ssp. *calcarata*** 100 (19); **EP** – *Calamagrostis varia* 33 (11), *Cirsium erisithales* 4 (11), *Erica carnea* 11 (14), *Galium austriacum* 22 (14), *Rosa pendulina* 4 (11); ***Epilobietea angustifolii*** **–** *Fragaria vesca* 21 (11), *Senecio ovatus* ssp. *ovatus* 4 (11); **FB** – *Asperula aristata* 13 (12), *Carex caryophyllea* 13 (15), *Gentiana germanica* 6 (6), *Polygala amarella* 8 (13); **JT** – *Carex curvula* ssp. *curvula* 13 (15), *Carex fuliginosa* 13 (15), *Festuca nigrescens* 6 (17), *Juncus jacquinii* 6 (17), *J. trifidus* 6 (17), *Leontodon helveticus* 22 (17), *Oreochloa disticha* 11 (17), *Veronica fruticans* 6 (17); **LV** – *Arctostaphylos alpina* 13 (12), *Loiseleuria procumbens* 11 (17); **M-Ar** – *Astrantia major* ssp. *major* 6 (8), *Deschampsia cespitosa* 46 (11), *Euphrasia picta* ssp. *picta* 13 (12), *Helictotrichon versicolor* 6 (17), *Poa annua* 11 (16), *P. supina* 100 (9), *Ranunculus tuberosus* 6 (12), *Senecio ovirensis* ssp. *gaudinii* 8 (11), *Vicia sepium* 6 (12); **MC** – *Chrysosplenium alternifolium* 63 (11); **MA** – *Aconitum*

napellus ssp. *tauricum* 14 (18), *Chaerophyllum hirsutum* 6 (8), *Cortusa matthioli* 14 (18), *Hypericum richeri* ssp. *grisebachii* 8 (11), *Pedicularis recutita** 6 (8), *Rumex alpestris* 6 (8), *Salix glabra* 14 (18), *S. hastata* 33 (14); **N** – *Antennaria dioica* 8 (13), *Carex leporina* 8 (13); **QF** – *Adoxa moschatellina* 8 (11), *Anemone nemorosa* 8 (11), *Aquilegia nigricans* 4 (11), *Athyrium filix-femina* 4 (11), *Cardamine enneaphyllos* 4 (11), *Cardamine trifolia* 4 (11), *Carex digitata* 29 (11), *Fagus sylvaticae* 4 (11), *Festuca altissima* 13 (11), *Hieracium murorum* 38 (11), *Homogyne sylvestris* 42 (11), *Lamium orvala* 4 (11), *Luzula luzuloides* ssp. *luzuloides* 25 (12), *Maianthemum bifolium* 17 (11), *Paris quadrifolia* 4 (11), *Phegopteris connectilis* 4 (11), *Poa nemoralis* 29 (11), *Primula elatior* 6 (8), *Salix alba* ssp. *alba* 6 (17), *Stellaria nemorum* ssp. *montana* 4 (11); **SH** – *Luzula alpinopilosa* ssp. *alpinopilosa* 22 (17); **SC** – *Carex nigra* 92 (10), *Gentiana utriculosa* 6 (12), *Luzula sudetica* 31 (12), *Phleum alpinum* 6 (17), *Pinguicula vulgaris* 6 (17); **TG** – *Seseli libanotis* 19 (12), *Veronica chamaedrys* agg. 6 (17); **VP** – *Aposeris foetida* 6 (8), *Clematis alpina* 25 (11), *Drypteris dilatata* 4 (11), *Lonicera caerulea* 46 (11), *Pyrola minor* 4 (11), *P. rotundifolia* 8 (10), *Rhododendron ferrugineum* 15 (13), *Vaccinium myrtillus* 50 (11), *Valeriana tripteris* 8 (11), *Veronica urticifolia* 4 (11); **Other species** – *Alchemilla* sp. 17 (8), 8 (11), 38 (15), 20 (19), *A. flabellata* 56 (12), 8 (13), *Festuca* sp. 44 (12), 8 (13), *Thymus* sp. 22 (8), 75 (15), *Alchemilla anisiaca* 6 (17), *A. sericoneura* 8 (13), *A. subcrenata* 6 (17), *A. vallesiaca* 29 (18), *Campanula* sp. 6 (8), *Erigeron* sp. 6 (17), *Hieracium* sp. 6 (8).

Less frequent geoelements to Table 2

E-Alp./Apenn. – 7, 8; Europ./SW-Asiat. – 3, 13; SW-Europ.-Mont. – 17; Illyr. – 11; N-Europ./Am. – 11; E-Europ. – 14; Europ./Mont. – 12; SE-Europ-Mont./NE-Europ. – 18; Medit.-Mont. – 1; E-Europ. – 11: 1; W-Alp.** – 19: 1; W-Europ. – 11.

List of syntaxa mentioned referred to in the text and Table 1

Thlaspietea rotundifolii Br.-Bl. 1948
Androsacetalia alpinae Br.-Bl. in Br.-Bl. & Jenny 1926
Drabetalia hoppeanae Zollitsch 1968
Thlaspietalia rotundifolii Br.-Bl. in Br.-Bl. & Jenny 1926
Thlaspion rotundifolii Jenny-Lips 1930
Petasition paradoxi Zollitsch ex Lippert 1966
Arabidetalia caeruleae Rübel ex Br.-Bl. 1949
Arabidion caeruleae Br.-Bl. in Br.-Bl. & Jenny 1926 em. Englisch 1999
Ranunculo traunfellneri-Festucetum nitidae (Wraber 1972) Englisch 1999
Saxifragetum stellaro-sedoidis Englisch 1999
var. geogr. *Achillea oxyloba* Surina 2005
var. geogr. *Ranunculus traunfellneri* Surina 2005
var. geogr. *Campanula pulla* Surina 2005
Saxifragetum hohenwartii Aichinger 1933
Salici herbaceae-Arabidion caeruleae Englisch 1999
Salici herbaceae-Arabidetum caeruleae Englisch 1999
Soldanello alpinae-Salicion retusae Englisch 1999
Salicetum retuso-reticulatae Br.-Bl. in Br.-Bl. & Jenny 1926
Homogyno discoloris-Salicetum retusae Aichinger 1933
Diantho alpinae-Salicetum retusae Englisch 1999
Selaginello selaginoidis-Salicetum reticulatae Englisch 1999
Salici retusae-Geranietum argentei Surina 2005
Potentillo brauneanae-Homogynetum discoloris Aichinger 1933
Salicion retusae Horvat 1949
Drepanoclado uncinati-Heliospermetum pusilli Surina & Vreš 2004
Elyno-Seslerietea Br.-Bl. 1948, *Seslerietalia juncifoliae* Horvat 1930, *Seslerion juncifoliae* 1930, *Caricion firmae* Gams 1936, *Gentiano terglouensis-Caricetum firmae* T. Wraber 1970, *Caricetum firmae* Rübel 1911, *Dryadetum octopetalae* Rübel 1911, *Salicetea herbaceae* Br.-Bl. 1948, *Salicion herbaceae* Br.-Bl. in Br.-Bl. & Jenny 1926, *Poo supinae-Cerastietum cerastoidis* Söyrinki ex Oberd. 1957, *Asplenietea trichomanis* (Br.-Bl. in Meier & Br.-Bl. 1926) Oberd. 1957, *Juncetea trifidi* Hadač in Hadač & Klika 1944, *Nardetea strictae* Rivas Goday & Borja Carbonell 1961, *Loiseleurio-Vaccinietea* Eggler 1952, *Montio-Cardaminetea* Br.-Bl. & Tüxen ex Klika & Hadač 1944 em. Zechmeister 1993, *Mulgedio-Aconitetea* Hadač & Klika in Klika & Hadač 1944, *Epilobietea angustifolii* Tüxen & Preising ex von Rochow 1951, *Scheuchzerio-Caricetea fuscae* Tüxen 1937, *Molinio-Arrhenatheretea* Tüxen 1937, *Festuco-Brometea* Br.-Bl. & Tüxen 1943, *Trifolio-Geranietea* Müller 1962, *Artemisietea vulgaris* Lohmeyer, Preising & Tüxen ex von Rochow 1951, *Erico-Pinetea* Horvat 1959, *Querco-Fagetea* Br.-Bl. & Vlieg. 1937, *Vaccinio-Piceetea* Br.-Bl. 1930 em. Zupančič 1976.

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IS VARIETY OF SPECIES-RICH SEMI-NATURAL *MESOBROMION* GRASSLANDS DETECTABLE WITH FUNCTIONAL APPROACH?

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ABSTRACT

The aim of the study was to compare how the relevés of species-rich dry grasslands (classis Festuco-Brometea*) in Central and Eastern Slovenia differ among each other on the basis of floristic composition and of 11 Plant Functional Traits (PFTs). On the basis of floristic structure and cover values, the relevés were classified in three well separated clusters. In the PCA ordination, the first axes suggested a gradient of soil pH, while the second, floristically based gradient, was interpreted as soil humidity. On the basis of selected traits, 3 PFTs were clustered, but not clearly interpreted. Despite differences in environmental parameters across Slovenia (climate, geographical position, altitude, soil conditions) and variety of land use disturbances – drivers of floristic variety, no discernible difference in vegetation structure in terms of selected plant traits were perceived by PCA ordination. It could be concluded that secondary dry grasslands share rather uniform functional types with not clearly detectable structural differences among them.*

Key words: dry grasslands, plant functional traits, plant functional types, *Festuco-Brometea*, land use, Slovenia, PCA, vegetation

LA VARIETÀ DEI PASCOLI ARIDI SEMI-NATURALI RICCHI DI SPECIE *MESOBROMION* È DISTINGUIBILE CON L'APPROCCIO FUNZIONALE?

SINTESI

Lo scopo del presente studio era quello di confrontare le differenze in composizione floristica e 11 caratteristiche funzionali della pianta (PTFs) di rilievi di pascoli aridi ricchi di specie (classi Festuco-Brometea*) nella Slovenia centrale ed orientale. Sulla base della struttura floristica e dei valori di copertura i rilievi sono stati classificati in tre gruppi ben separati. Nell'ordinamento PCA il primo asse propone un gradiente del pH del suolo, mentre il secondo gradiente floristico viene interpretato come umidità del suolo. Tre PFTs sono stati inoltre raggruppati in base alle caratteristiche selezionate, ma non sono stati chiaramente interpretati. Nonostante le differenze nei parametri ambientali da un capo all'altro della Slovenia (clima, posizione geografica, altitudine, condizioni del suolo), e la varietà di disturbi legati all'impiego del suolo – piloti della varietà floristica, l'ordinamento PCA non ha percepito differenze discernibili nella struttura della vegetazione in termini di caratteristiche funzionali della pianta selezionate. Gli autori concludono che i pascoli aridi secondari condividono tipi funzionali della pianta uniformi che tra loro non presentano differenze strutturali chiaramente visibili.*

Parole chiave: pascoli aridi, caratteristiche funzionali della pianta, tipi funzionali della pianta, *Festuco-Brometea*, impiego del suolo, Slovenia, PCA, vegetazione

INTRODUCTION

Vegetation science has been essentially based on species composition, which has been needed for vegetation description, but this view has been criticized (*e.g.* Grime, 1979; Ghiselin, 1987). There has been an increasing interest in using non-phylogenetic based classifications when predicting the dynamics of vegetation rather than their taxonomic identity (Gitay, 1999; Cornelissen *et al.,* 2003). On a large scale, predictions based on plant species are geographically bound (Woodward & Cramer, 1996). On a small scale, species are in some instances so broad and variable that by describing communities by species composition we may not perceive relevant patterns of vegetation occurring below the resolving power of species (Diaz *et al*., 1992). Classifying plant species according to their taxonomy has strong limitations when it comes to answering important ecological questions at the scale of ecosystems, landscapes or biomes (Woodward & Diament, 1991; Keddy, 1992; Körner, 1993). These questions include those on responses of vegetation to environmental variation or changes, notably in climate, atmospheric chemistry, land use and natural disturbance regimes. A promising way for answering such questions (and many other ecological questions) is by classifying plant species on functional grounds (Diaz *et al*., 2002). These alternative classes are often referred to as plant functional types (PTFs) or groups (Grime *et al*., 1988; Leishman & Westoby, 1992; Gitay & Noble, 1997).

Classifying plants according to morphology and reproductive attributes has a long history in botany and plant geography (Kleyer, 1999). Functional classifications of species were already searched for by natural philosophers and ecologists. Theophrastus (ca. 300 B.C.) classified plants into trees, shrub, and herbs (Morton, 1981). This and some other classifications used in the past may be viewed as predecessors of what are now called plant functional types (Kleyer, 1999). An example still in practice is the life-form approach of Raunkiaer (1934), modified and improved by Ellenberg & Mueller-Dombois (1974). Although introduced long time ago (Raunkiaer, 1934; Grime, 1977; Noble & Slatyer, 1980; Box, 1981, 1996), the concept of PFTs has received new attentions as a possible framework for predicting ecosystem response to human-induced changes at a global scale (Diaz & Cabido, 1997).

The aim of the study was to test if the territory of Slovenia, covering only 21,000 km^2 (here even excluding the Alps and the sub-Mediterranean), is enough variable to support different functional types consisting secondary dry grasslands. Environmental conditions (climate, phytogeographic position, altitude and soil parameters) are quite different across Slovenia, and Slovenian vegetation is considered one of the most diverse in the world outside the tropics in terms of species numbers (Watts, 2004).

In this paper we aim to identify main types of Slovenian secondary semi-dry grasslands of *Bromion erecti* alliance (class *Festuco-Brometea*) on the basis of floristic composition and 11 plant functional traits. The data set includes 67 relevés of Central and Eastern Slovenian semi-dry grasslands and matrix with 11 traits recorded on 155 plant species. Our main objectives were: (1) to search for 11 selected plant functional traits (PFTs) for plant species occurring on semi-dry grasslands of *Mesobromion* alliance in Central and Eastern Slovenia, using the literature and herbaria sources; (2) to identify PFTs in Slovenian semi-dry grasslands on the basis of selected traits; (3) to compare community types derived from plant functional classification based on traits and classification based on species.

Plant functional types are non-phylogenetic groupings of species and can be defined as groups of plant species sharing similar functioning at the organismic level, similar responses to environmental factors (*e.g.* temperature, water availability, nutrients, fire and grazing), and/or similar roles in (or effects on) ecosystems or biomes (*e.g.* productivity, nutrient cycling, flammability and resilience) (Walker, 1992; Chapin *et al.*, 1996; Nobble & Gitay, 1996; Diaz & Cabido, 1997; Lavorel *et al.*, 1997; Grime, 2001). Species comprising a functional type share a set of key functional traits.

According to Allen & Starr (1982), the functional type is a multi-species level of organization, lying above the population but below the community (*cit.* Hunt *et al.*, 2004). They could also be characterized as plant strategies, which can be defined as groupings of similar or analogous genetic characteristics, which recur widely among species or populations and cause them to exhibit similarities in ecology (Grime, 2002).

The first step in defining PFTs is to choose a list of key traits that are believed to be important for both understanding and prediction of phenomena relevant for our research. The sets of traits or types differ among applications (Woodward & Cramer, 1996). The traits must be observable expressions of forms or behaviours defining plant types that are responsive, in terms of occurrence or performance, to changes in ecosystem conditions.

Plant traits can be obtained by measurements in the filed, laboratory, or from the literature. They usually refer to **life-history** (life span, life-cycle), **morphology** (plant height, lateral spread, life form, spinescence, specific leaf area (SLA), leaf size ...), and **regeneration** (*e.g.* seed characters - size and mass, recruitment frequency, dispersal mode, ability to reproduce vegetative, flowering period ...).

MATERIAL AND METHODS

Material

Slovenia, situated at ca. 46°N, 14°E in the contact area of the Alps, Dinarids, Mediterranean and Pannonian plain, has a relief consisting of plains, hilly regions, highlands, mountains etc. 40% of the land is underlain by carbonate rocks, mainly well karstified and dolomatised (Watts, 2004).

We analysed 10 published (Škornik, 2003) and 57 unpublished (Škornik, 2000) vegetation relevés of *Bromion erecti* dry and semi-dry grassland (order *Brometalia erecti*, class *Festuco-Brometea*). Relevés were collected in Central, Eastern, South- and North-eastern Slovenia using standard procedure of the Braun-Blanquet approach (Braun-Blanquet, 1964; Westhoff & van der Maarel, 1973; Dierschke, 1994). For analysis of plant traits, we selected all the species, which were present in at least 5% of the relevés. The total number of species considered was 155.

Plant traits selection

In choosing key traits we followed different literature sources (Hodgson *et al.*, 1999; Kahmen *et al.*, 2002; Cornelissen *et al.*, 2003). For the purpose of this study we compiled a data-base of 11 morphological, life-history and regeneration traits, measurable at the individual plant level, using the literature data, data from herbaria and supplemented by our own observations. The scale of measurement of plant traits was originally continuous or categorical, but they were all transformed into categorical scales for analyses (Tab. 1).

The list of traits with description of classes in matrix and the source of information are presented in Table 1.

The procedure of this study was to classify the species of Slovenian species rich semi-natural *Mesobromion* grasslands into species groups of similar functional traits by using multivariate statistics.

Data analysis

To identify the main dry grassland types, we built a 155 species x 67 relevés matrix (all matrices available by authors on request). This matrix was then subjected to standard multivariate classification (agglomerative cluster analysis) and ordination techniques (PCA) (software SYN-TAX 2000 (Podani, 2001)).

The scales of measurements of plant attributes were originally continuous, categorical or binary, but they were all transformed into categorical or binary scales prior to the analysis. In order to identify groups of species with similar traits, we built an 11 traits x 155 species matrix. We submitted the matrix to a Principal Component Analysis (PCA) based on correlation matrix

Tab. 1: Plant traits, recorded on 155 vascular plant species of dry and semi-dry grasslands from Central, South, North-eastern and Eastern Slovenia with description of classes in matrix. Scales of measurement were originally categorical (cat), continuous (cont) or binary (bin).
Tab. 1: Rastlinski znaki, zbrani za 155 rastlinskih vrst suhih in polsuhih travišč iz osrednje, južne, severovzhodne in vzhodne Slovenije z opisi razredov v matriki. Originalni podatki so v obliki kategorij (cat), zvezni (cont) ali binarni (bin).

Trait		Classes in the matrix
Life form [3, *]	cat	1 = Chamaephytes
		2 = Geophytes
		3 = Hemicryptophytes
		4 = Phanerophytes
		5 = Therophytes
Life cycle [3, *]	cat	1 = Annual
		2 = Biennial
		3 = Perennial
Growth form [3, 5, *]	cat	1 = Tussocks
		2 = Rosette
		3 = Leafy stem
		4 = Rosette and leafy stem
Plant height [1, 4 ***]	cont	1 = < 5 cm
		2 = 5 – 25 cm
		3 = 25 – 75 cm
		4 = 75 – 125 cm
		5 = 125 – 150 cm
		6 > 150 cm
Stolons [1, 3, 5, *]	bin	0 = Absent
		1 = Present
Rhizomes [1, 3, 5, *]	bin	0 = Absent
		1 = Present
Storage organs [1, 3]	cat	1 = Absent
		2 = Tubers
		3 = Bulbs
		4 = Rhizomes
Spinescence [1, 4, **]	bin	1 = None
		1 = Present
Hairiness [1, 3, 4]	cat	1 = No
		2 = Low
		3 = High
Flowering start [1, 4, ***]	cat	1 = in March or earlier
		2 = in April
		3 = in May
		4 = in June
		5 = in July
		6 = in August or later or before leaves in spring
Potential allelochemicals [1, 2]	bin	0 = Absent
		1 = Present

Data source for traits:
[1]Hegi (1958, 1963, 1964, 1965, 1966, 1987a, 1987b); [2]Petauer (1993); [3]Martini *et al.* (1999); [4]Poldini (1991); [5]Rothmaler (1995); [6]Heywood (1995); [7]Heywood *et al.* (1980, 1972, 1968, 1964); [8]Lauber & Wagner (1998); [9]Wraber & Seliškar (1986); [10]Wraber (1990); [11]Grey-Wilson (1998)
References for classis formation in matrix:
[*] Kahmen *et al.* (2002)
[**] Cornelissen *et al.* (2003)
[***] Hodgson *et al.* (1999)

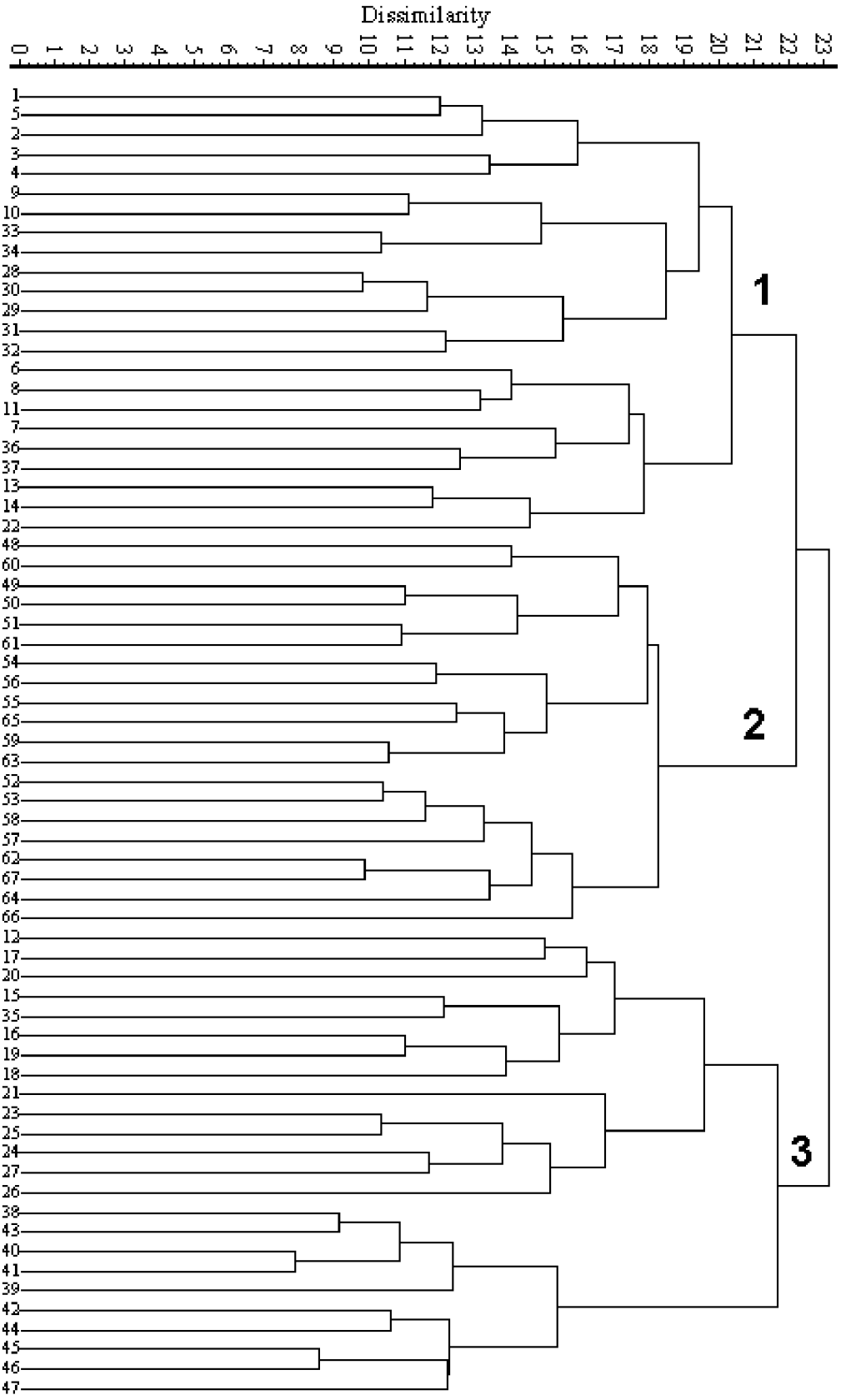
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Fig. 1: Dendrogram: the result of the hierarchical clustering of 67 relevés of *Mesobromion erecti* ***dry grasslands, collected in the territory of Central, Eastern, South- and North-eastern Slovenia. Numbers on dendrogram represent the following relevés from the original tables:***
No. 1-27: ***Škornik (2000): Tab. 11, relevés No. 3, 4, 6, 7, 8, 15, 30, 33, 37, 40, 43, 46, 47, 49, 51, 52, 53, 55, 59, 64, 75, 77, 80, 81, 84, 85 and 86;*** *No. 28-37:* ***Škornik (2000): Tab. 6, relevés No. 6, 10, 12, 14, 15, 16, 17, 20, 25 and 26;*** *No. 38-47:* ***Škornik (2003): Tab. 2, relevés No. 7, 8, 9, 10, 11, 12, 13, 23, 24 and 25;*** *No. 48-67:* ***Škornik (2000): Tab. 1, relevés No. 13, 21, 22, 24, 39, 40, 43, 54, 55, 56, 63, 64, 72, 73, 83, 84, 90, 96, 102 and 103. Cluster numbers are indicated on the dendrogram.***
Sl. 1: Dendrogram: rezultat hierarhične klasifikacije 67 popisov suhih travišč iz zveze *Mesobromion erecti****, zbranih na območju osrednje, vzhodne, južne in severovzhodne Slovenije. Številke v dendrogramu predstavljajo naslednje popise v originalnih tabelah:***
Št. 1-27: ***Škornik (2000): Tab. 11, popisi št. 3, 4, 6, 7, 8, 15, 30, 33, 37, 40, 43, 46, 47, 49, 51, 52, 53, 55, 59, 64, 75, 77, 80, 81, 84, 85 in 86;*** *Št. 28-37:* ***Škornik (2000): Tab. 6, popisi št. 6, 10, 12, 14, 15, 16, 17, 20, 25 in 26;*** *Št. 38-47:* ***Škornik (2003): Tab. 2, popisi št. 7, 8, 9, 10, 11, 12, 13, 23, 24 in 25;*** *Št. 48-67:* ***Škornik (2000): Tab. 1, popisi št. 13, 21, 22, 24, 39, 40, 43, 54, 55, 56, 63, 64, 72, 73, 83, 84, 90, 96, 102 in 103. Številke klastrov so označene na dendrogramu.***

of variables, in which data are cantered and standardized by standard deviation, which is considered appropriate for mixed data (Jongman *et al.*, 1987). The species cluster was assumed to represent PFTs at the species level (Keddy, 1992; Garcia Mora *et al.*, 1999).

In order to identify the predominant plant traits for Slovenian semi-dry grassland vegetation, the matrix of 11 traits by 155 species was multiplied by the matrix of 155 species x 67 relevés. The result was a matrix of 11 traits x 67 relevés that was analysed by means of PCA.

Nomenclature

Taxonomic nomenclature follows Martinčič *et al.* (1999), while syntaxonomic nomenclature follows Mucina & Kolbek (1993).

RESULTS AND DISCUSSION

Floristic analysis

Figure 1 shows the results of the hierarchical clustering of 67 relevés of dry and semi-dry grasslands. Through the analysis of the species x sites matrix, the main types of dry and semi-dry grasslands could be distinguished.

Cluster 1: 23 relevés of grasslands collected on very shallow Rendzinas and Chromic Cambisols on Limestone mainly from Dinaric, Predinaric and pre-Alpine regions at higher altitudes. These grasslands occur on very shallow and warm soils with basic pH. Characteristic species of the cluster are *Carex humilis, Plantago holosteum, Polygala chamaebuxus, Gentiana verna* subsp. *tergestina, Knautia illyrica, Tragopogon tommasinii, Pseudolysimachion barrelieri* subsp. *barrelieri, Anthericum ramosum*, etc.

Cluster 2: 20 relevés of semi-dry grasslands on Eutric Cambisols on tertiary bedrock (limestone or flysch). These soils represent eutrophic (mesic) sites, rich with nutrients due to the deeper profile, containing more humidity and having basic to slightly acid pH. Favourable conditions result high and dense grassland stands with some dominant grass species *(e.g. Bromus erectus* agg., *Briza media, Dactylis glomerata, Koeleria pyramidata*, …). Other indicator species are *Onobrychis viciifolia, Arrhenatherum elatius, Daucus acrota, Galium mollugo, Trisetum flavescens, Poa angustifolia, Medicago lupulina, Viccia cracca, Lathyrus pratensis* and many other species of more fertile and moist grasslands are frequent.

Cluster 3: 24 relevés of grassland stands on acid soils. First 14 relevés present stands on acid and leached soils on calcareous substrate (limestone, dolomite) from the central part of Dolenjska region and from Bela krajina. Last 10 relevés were collected on sandstone hilly area of Goričko (NE Slovenia), where they occur on acid soils (mainly Ranker and Pseudogleys) developed on non-carbonate substrate. Species, which are characteristic for these relevés, are typical acidophilus species like *Agrostis tenuis, Festuca filiformis, Carex pallescens, Luzula campestris, Hieracium pilosella, Cynosurus cristatus, Potentilla erecta* and *Danthonia decumbens*.

In the PCA ordination, the three clusters appeared well separated (Fig. 2). Dispersion of relevés along the first axis of the PCA (PCA1) suggested a gradient of soil pH, while the second floristically based gradient along PCA2 axis was interpreted as soil humidity. Most clearly separated group of relevés is located at the left extreme of the first gradient (diamonds) and represents dry grasslands from the Goričko region, which occupies very acid and dry sites. Above the middle of the PCA-ordination there are grassland stands from the second cluster (squares), which are characteristic of moderately humid and mainly neutral soils. The third group of relevés could represent the mixture of relevés from clusters 1 and 3 (circles, diamonds). At the right extreme of the first PCA axis, we found stands with the most basic and moderately humid conditions.

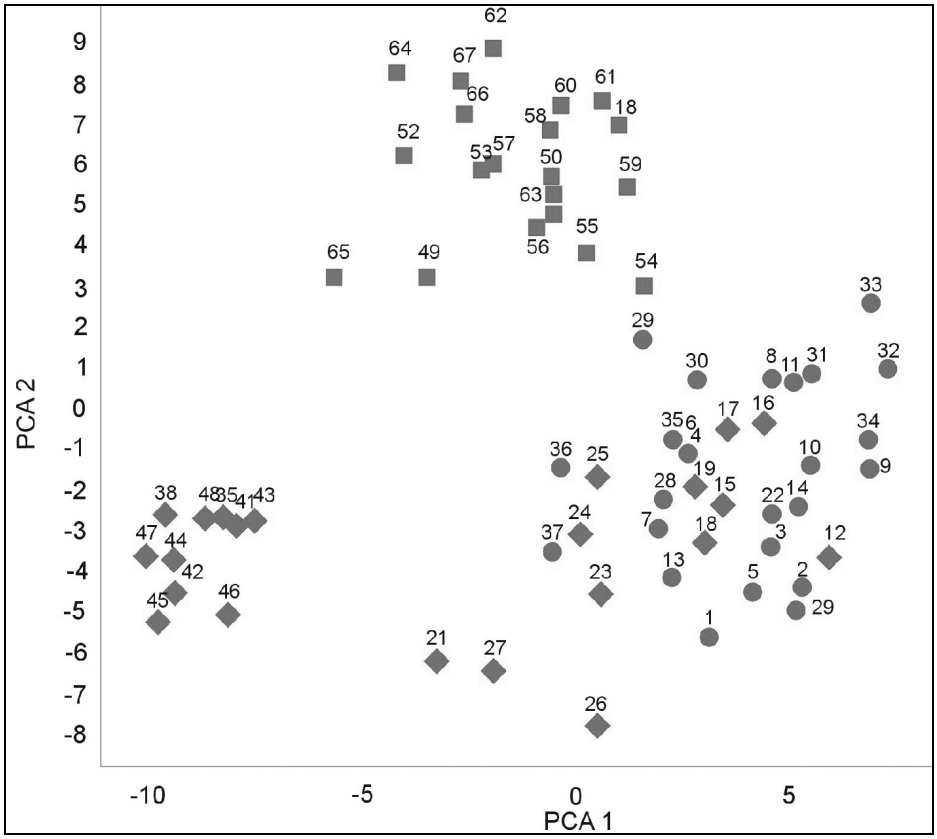

Fig. 2: PCA: ordination of 155 species x 67 sites matrix. Numbers correspond to the relevé numbers in figure1. Legend: circles = 1st cluster, squares = 2nd cluster, diamonds = 3rd cluster.
Sl. 2: PCA: ordinacija matrike 155 vrst x 67 popisov. Številke se ujemajo s številkami popisov na sliki 1. Legenda: krogec = klaster št. 1, kvadrat = klaster št. 2, karo = klaster št. 3.

It could be concluded that the studied dry grasslands differ according to their floristic composition as the consequence of different environmental parameters (climate, geographical position, altitude, soil conditions...) and disturbance of land use.

Plant functional types

We distinguished three groups (clusters) of plant species on the basis of the hierarchical classification of the traits x species. Detailed analysis of clusters is presented in Table 2. First group included 100 species. They were mostly perennial species (91%) and hemicryptophytes (74%). In comparison with the other two groups, there was the highest percentage of chamaephytes (14%). More than half of the plants had leafy stem and almost a quarter (24%) were tussock-forming species, which indicates that this group was rich in grasses *(e.g. Anthoxanthum odoratum, Arrhenatherum elatius, Avenula pubescens, Briza media, Danthonia decumbens, Festuca pratensis…*). Half of them were of medium height, namely 25-75 cm (52%). 75% of the species had no stolons and no rhizomes (82%). They were mostly without storage organs (88%), spineless (95%) and started to flower in early summer (May, June).

The second group (16 species) had the highest portion of therophytes and consequently the main part of annuals. In the second group, the major part of biennials (31.3%) were also classified. Species had mainly leafy stem, they were all without stolons and more than half of them had rhizomes (*e.g. Campanula patula, Cirsium pannonicum, Crepis biennis, Daucus carota, Leucanthemum vulgare…).* All the species from the second group started to flower in May or June. They often contained potential allelochemical compounds (62.5%). All the species from the third group (39) were hemicryptophytes, perennial and without stolons. In comparison with the 1st and 2nd groups, this group had the highest proportion of species with rosette (61.5%), species with rhizomes (79.5%), and species with high hairiness (66.7%).The traits *storage organs* and *spinescence* exhibited no evident differences between clusters of species. Therefore we could summarize our PFTs analysis with conclusion that there are no clear PFTs distinguished on the basis of the classification of the traits x species matrix. This indicates that for the species occur-

Tab. 2: PFT analysis for three groups (clusters) of plant species, defined by the hierarchical classification of the traits x species matrix. Values represent the proportion (in %) of species within the cluster.
Tab. 2: Analiza po znakih za 3 skupine (klastre) rastlinskih vrst, dobljenih na podlagi hierarhične klasifikacije matrike znaki x vrste. Številke predstavljajo deleže (v %) vrst v posameznem klastru.

Trait		Cluster 1	Cluster 2	Cluster 3
Life form	Chamaephytes	14	12.5	0
	Geophytes	7	12.5	0
	Hemicryptophytes	74	56.3	100
	Phanerophytes	0	0	0
	Therophytes	5	18.8	0
Life cycle	Annual	5	18.8	0
	Biennial	4	31.3	0
	Perennial	91	50	100
Growth form	Tussocks	24	0	15.4
	Rosette	5	0	35.9
	Leafy stem	51	75	23.1
	Rosette and leafy stem	20	25	25.6
Plant height	< 5 cm	0	0	2.6
	5 – 25 cm	46	31.3	28.2
	25 – 75 cm	52	43.8	59
	75 – 125 cm	2	25	10.3
	125 – 150 cm	0	0	0
	> 150 cm	0	0	0
Stolons	Absent	75	100	100
	Present	25	0	0
Rhizomes	Absent	18	68.8	79.5
	Present	82	31.3	20.5
Storage organs	Absent	88	87.5	82.1
	Tubers	7	0	0
	Bulbs	2	0	0
	Rhizomes	3	12.5	18
Spinescence	None	95	93.8	97.4
	Present	5	6.3	2.6
Hairiness	No	45	31.3	20.5
	Low	21	43.8	12.8
	High	34	25	66.7
Flowering Start	in March or earlier	5	0	10.3
	in April	13	0	12.8
	in May	39	50	35.9
	in June	36	50	23.1
	in July	6	0	15.4
	in August or later or before leaves in spring	1	0	2.6
Potential allelochemicals	Absent	55	37.5	35.9
	Present	45	62.5	64.1
No. of species in cluster		**100**	**16**	**39**

ring on the studied semi-dry grasslands no easy-interpreting groupings of species on the basis of selected traits could be noted. PCA ordination of 11 traits x 67 relevés matrix (Fig. 3) is confirming the conclusion given above. Floristically well separated relevés (marked with different colours on figure 1) are scattered irregularly in this PCA ordination. Groups of morphologically (functionally) similar relevés could not be recognized. Since there was no discernible difference in vegetation structure in terms of measured plant traits, it could be concluded that secondary dry grasslands share rather uniform functional types. This may be due to the lack of strong species turnover (Diaz *et al.*, 1999), which may mask structural differences.

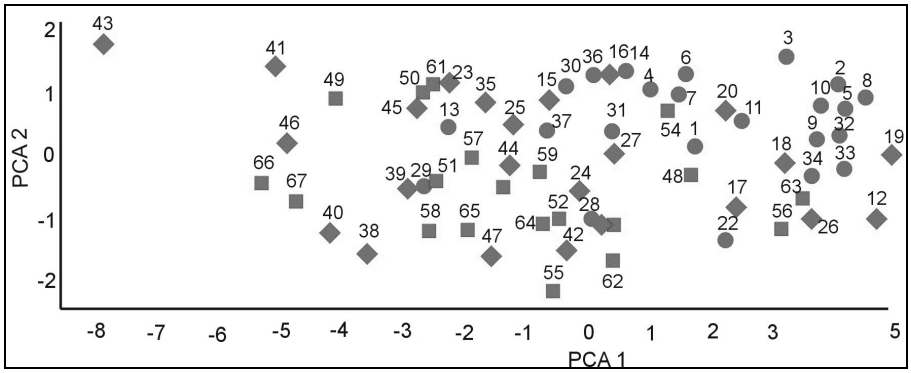

Fig. 3: PCA: ordination of 11 traits x 67 relevés matrix. Numbers correspond to the relevé numbers in figure1. Legend: circles = 1st cluster, squares = 2nd cluster, diamond = 3rd cluster.
Sl. 3: PCA: ordinacija matrike 11 znakov x 67 popisov. Številke se ujemajo s številkami popisov na sliki 1. Legenda: krogec = klaster št. 1, kvadrat = klaster št. 2, karo = klaster št. 3.

ALI JE RAZNOLIKOST POLSUHIH VRSTNO BOGATIH TRAVIŠČ ZVEZE *MESOBROMION* MOGOČE ZAZNATI S FUNKCIONALNIM PRISTOPOM?

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POVZETEK

Cilj avtorjev tega članka je bil ugotoviti osnovne tipe slovenskih sekundarnih polsuhih travišč iz zveze Mesobromion erecti *(razred* Festuco-Brometea*) na osnovi floristične sestave in 11 rastlinskih funkcionalnih potez (znakov). Analizirane podatke predstavljata matrika s 67 objavljenimi in neobjavljenimi fitocenološkimi popisi polsuhih travišč iz območij osrednje in vzhodne Slovenije ter matrika z 11 funkcionalnimi potezami, ki smo jih zbrali za 155 rastlinskih vrst teh polsuhih travišč. Podatke smo obdelali s standardnimi multivariatnimi metodami – metodo hierarhične klasifikacije ter ordinacijsko metodo glavnih komponent (PCA).*

Na osnovi floristične strukture in vrednosti za pokrovnost so se popisi klasificirali v tri dobro ločene skupine (klastre). Tudi v PCA ordinacijskem diagramu so bile te tri skupine lepo prepoznavne. Sklepali smo, da predstavlja prva ordinacijska os (x os) gradient pH tal, druga PCA os (y os) pa gradient vlažnosti.

Za določitev značilnih rastlinskih znakov vrst polsuhih travišč smo matriko znaki x vrste pomnožili z matriko vrste x popisi. Kot rezultat smo dobili matriko znaki x popisi, ki smo jo nato analizirali z ordinacijsko metodo glavnih komponent (PCA analiza). Na osnovi zbranih znakov so se rastlinske vrste klasificirale v tri skupine, ki pa jih je bilo težko interpretirati v smislu funkcionalnih tipov. Tako smo ugotovili, da kljub razlikam v okoljskih parametrih (podnebje, geografska lega, nadmorska višina, tip tal, inp.) in njihovi različni rabi na podlagi izbranih rastlinskih znakov ter s pomočjo ordinacijske metode ni bilo mogoče zaznati razločnih razlik v strukturi vegetacije. Zaključili smo, da se na preučevanih polsuhih traviščih pojavljajo precej enotni funkcionalni tipi s težko določljivimi razlikovalnimi znaki.

Ključne besede: suha travišča, rastlinski funkcionalni znaki, rastlinski funkcionalni tipi, *Festuco-Brometea*, raba tal, Slovenija, PCA, vegetacija

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IDENTIFICATION AND CHARACTERIZATION OF AUTOCHTHONOUS OLIVE VARIETIES IN ISTRIA (CROATIA)

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ABSTRACT

With the aim of solving the confusion regarding the names of autochthonous olive varieties in Croatian Istria, their inventarization and identification was made. Morphological description of 64 olive trees was performed and samples were clustered in 6 potential variety groups with at least 14 different varieties.

Key words: olive, autochthonous varieties, morphological characteristics

IDENTIFICAZIONE E CARATTERIZZAZIONE DI VARIETÀ AUTOCTONE DI ULIVI IN ISTRIA (CROAZIA)

SINTESI

Allo scopo di dissolvere la confusione creatasi in merito ai nomi delle varietà autoctone di ulivi nell'Istria croata, gli autori hanno preparato l'inventario e l'identificazione di tali specie. L'articolo fornisce una descrizione morfologica di 64 alberi di ulivo. I campioni sono stati divisi in 6 potenziali gruppi con almeno 14 differenti varietà.

Parole chiave: ulivo, varietà autoctone, caratteristiche morfologiche

INTRODUCTION

Olive *(Olea europea* L.), the species characteristic of the Mediterranean landscape, includes a large number of varieties with significant phenotypic and genetic diverseness (Ziliotto *et al.*, 2002; Idrissi & Quazzani, 2003). In Croatia, olives are spread in all coastal regions, such as Istria, Kvarner, Dalmatia and their islands. The first historical records regarding olive growing in Istrian region date to the first century BC (Hugues, 1999). According to the latest official statistical data, about 11% of a total 2,432,653 olive trees in Croatia are cultivated in Istria (Central Croatian Bureau of Statistics, www.dsz.hr). Lately, the traditional extensive olive cultivation methods were replaced with intensive modern growing technology, making olive growing an attractive trend in agriculture. Despite a large biological variability and economic potential, there has been no systematic inventarization and description of local olive varieties in Croatian Istria. The first attempt to describe and classify local varieties following his own original system was made by Hugues in 1903 (Hugues, 1999).

Olive cultivars show a broad range of genetic variability for a large number of agronomic traits, including oil quality and content, fruit size and degrees of adaptability to environmental conditions. The ability to discriminate olive cultivars and to estimate genetic variability is an important factor for a better management of genetic resources and successful breeding programs. With this aim, we started with a few research projects focused on the most important aspects of olive growing and oil production (Peršurić *et al.*, 2004). The project named "Valorisation of autochthonous olive varieties in Istria" comprises identification, characterization, clonal selection and certificated seedlings production.

Olive trees are spread along the entire Istrian peninsula (Central Croatian Bureau of Statistics, www.dsz.hr), mostly in coastal zone around the districts of Vodnjan, Poreč, Buje, Brtonigla, Umag, Rovinj and Pula (Fig. 1). The most frequent varieties are traditionally named: *buža, rosulja, bjelica* and *crnica*.

In this paper we present the results of a three-year investigation, including morphological descriptions of 64 olive accessions and preliminary variety determination.

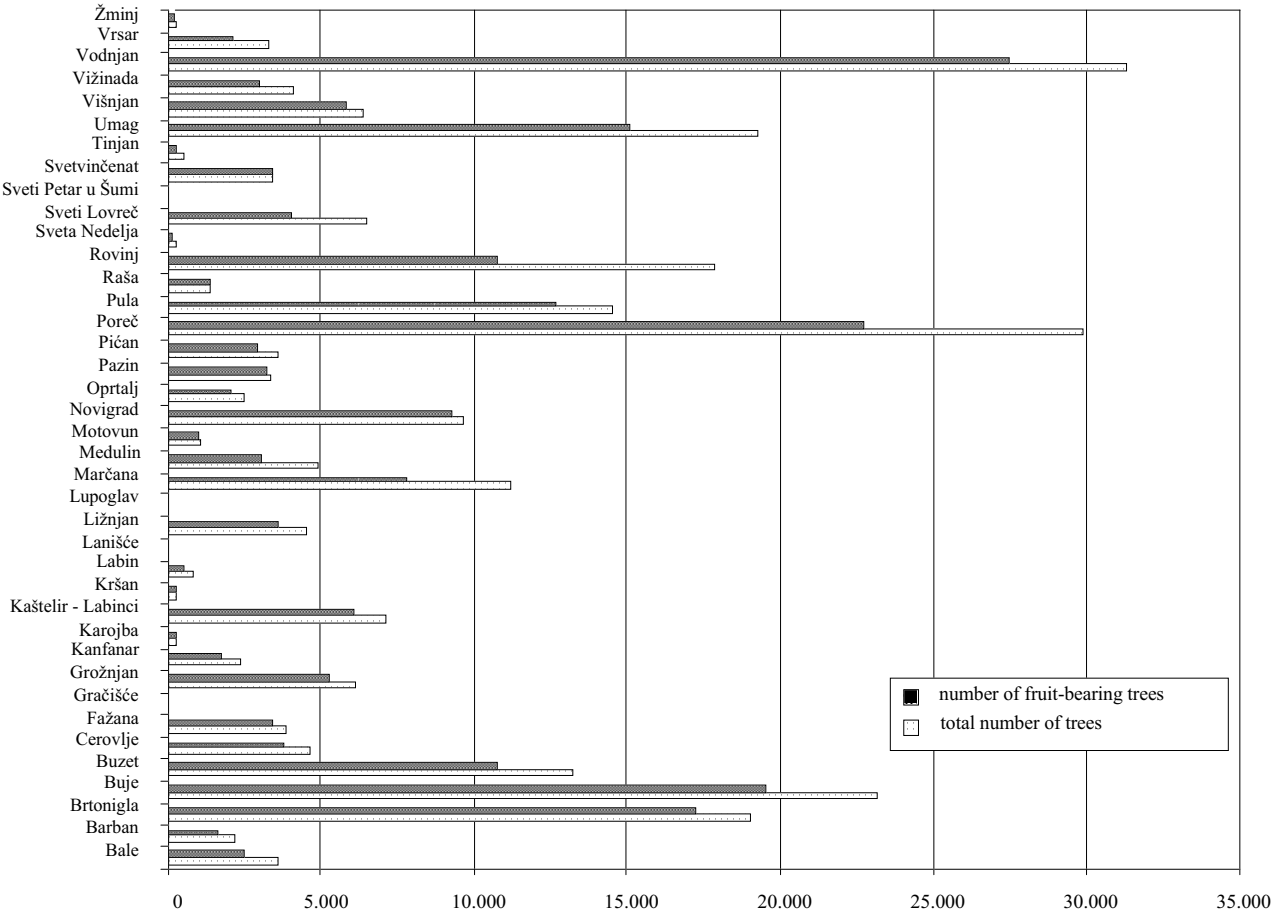

Fig. 1: Olive trees distribution in Istrian County.
Sl. 1: Razširjenost oljk v Istri.

Tab. 1: List of analysed morphological characteristics according to International Olive Oil Council (COI).
Tab. 1: Seznam analiziranih morfoloških značilnosti po priporočilih Mednarodnega sveta za olivno olje (COI).

Analysed morphological characteristics	Category
LEAF (2 characteristics)	
Form	1. elliptic
	2. elliptic-lanceolate
	3. lanceolate
Curvature	1. hyponastic
	2. flat
	3. epinastic
	4. helicoidal
INFLORESCENCE (2 characteristics)	
Length	1. short
	2. medium
	3. long
Number of flowers	1. scarce
	2. medium
	3. high
FRUIT (9 characteristics)	
Shape	1. spherical
	2. oval
	3. elongated
Symmetry	1. symmetrical
	2. weakly asymmetric
	3. asymmetrical
Position of maximum transversal diameter	1. towards base
	2. central
	3. towards apex
Shape of apex	1. pointed
	2. rounded
Shape of base	1. truncated
	2. rounded
Mamelon	1. absent
	2. weakly present
	3. evident
Presence of lenticels	1. sparse
	2. numerous
Dimension of lenticels	1. small
	2. large
Ripeness start	1. from base
	2. uniform
	3. from apex
ENDOCARP (10 characteristics)	
Shape	1. spherical
	2. oval
	3. elliptic
	4. elongated
Symmetry (position A)	1. symmetrical
	2. weakly asymmetric
	3. asymmetrical
Symmetry (position B)	1. symmetrical
	2. weakly asymmetrical
Position of maximum transversal diameter	1. towards base
	2. central
	3. towards apex
Apex	1. pointed
	2. rounded
Base	1. truncated
	2. pointed
	3. rounded
Surface	1. smooth
	2. rugose
	3. scabrous
Number of fibrovascular grooves	1. reduced
	2. medium
	3. elevated
Distribution of fibrovascular grooves	1. uniform
	2. grouped around suture
Bill of apex	1. without mucro
	2. with mucro

MATERIALS AND METHODS

Plant material was collected in the entire Istrian area, after accurate field observations and study of distribution density on the territory. Chosen accessions represent the old and most valuable cultivars, traditionally named *buža, crnica, karbonaca, karbonera, črnica, rosulja, rosinjola, rošola, istarska bjelica, belica, bilica, bjankera, domaća, plominka* and others. Morphological description was performed on 64 olive trees according to International Olive Oil Council standards (COI, 1997). Altogether, 23 characteristics of leaf (2), inflorescence (2), fruit (9) and stones (10) were measured during three years (Tab. 1). Some characters like inflorescence length and flower number can vary due to exogenous factors (environment, cultivation technology, etc). In case of uncertainty in category defining, measuring was repeated on the larger sample and prevailing category was taken under consideration.

The data have been analysed using the STATISTICA 5.0 program. Accessions were grouped by cluster analysis using the Unweighted pair-group method (UPGMA) with the Squared Euclid distance.

RESULTS AND DISCUSSION

Results obtained by morphological description enabled us to partially clarify the actual confusion as to the naming of various varieties. Accessions were grouped in 6 main clusters with different potential varieties (Fig. 2, Tab. 2). The first cluster contained the largest number of samples described as istarska bjelica, bjelica, buža, črna, črnica and plominka. Samples belonging to bilica, črna and črnica were grouped in the second cluster, karbonaca and drobna in the third, belica, karbonera, bilica, črnica and rosinjola in the fourth cluster. One sample was set apart and considered as separate variety named moražo. In the sixth cluster, a few potential varieties, all named duga were grouped.

So far, the analyses assumed 14 potential varieties, but considering that there are significant differences even between accessions, it can be expected that the number of varieties could be higher. Appropriate names and main variety characteristics are given in Table 3. Numerous synonyms indicating local varieties that caused present confusion in their naming are not only the consequence of a millennium long olive presence in Istria but also of phenotypic variability between genetically similar individuals, due to environmental conditions.

During data processing, problems with similar variety names, homonyms and synonyms have emerged. Despite some very similar local variety names, such as istarska bjelica, bilica, bjelica and belica, they showed different morphologic profiles and were clustered in distinctive groups, supporting our assumption about differ-

Tab. 2: List of investigated accessions with potential variety classification.
Tab. 2: Seznam preučevanih oljk s klasifikacijo potencialnih sort.

Accession numbers	Potential variety
1-5	Istarska bjelica
6	Non defined
7-10	Bilica
11-12	Duga
13-15	Belica
16-17	Bjelica
18-21	Buža
22-27	Črna
28-31	Duga
32-33	Buža
34-35	Črnica
36	Buža
37-44	Črnica
45	Karbonera
46-49	Karbonaca
50-52	Črnica
53-54	Drobna
55	Moražo
56	Karbonaca
57-60	Plominka
61-64	Rosinjola

ent varieties. The same situation was observed with respect to črnica, crnica, karbonera and karbonaca. Aimed at solving homonym problems with different accessions named buža we left the traditional name only for accessions from the south areas of Istrian County (Vodnjan, Bale), where they are grown mostly in old plantations, and chose new names for homonyms at other localities. On the other hand, some differently named accessions seemed to be synonyms, and were classified under the same name.

This inventarization and preliminary classification provided us a base for further research. Subsequent morphological investigations and DNA analyses will additionally clarify the so far reached considerations.

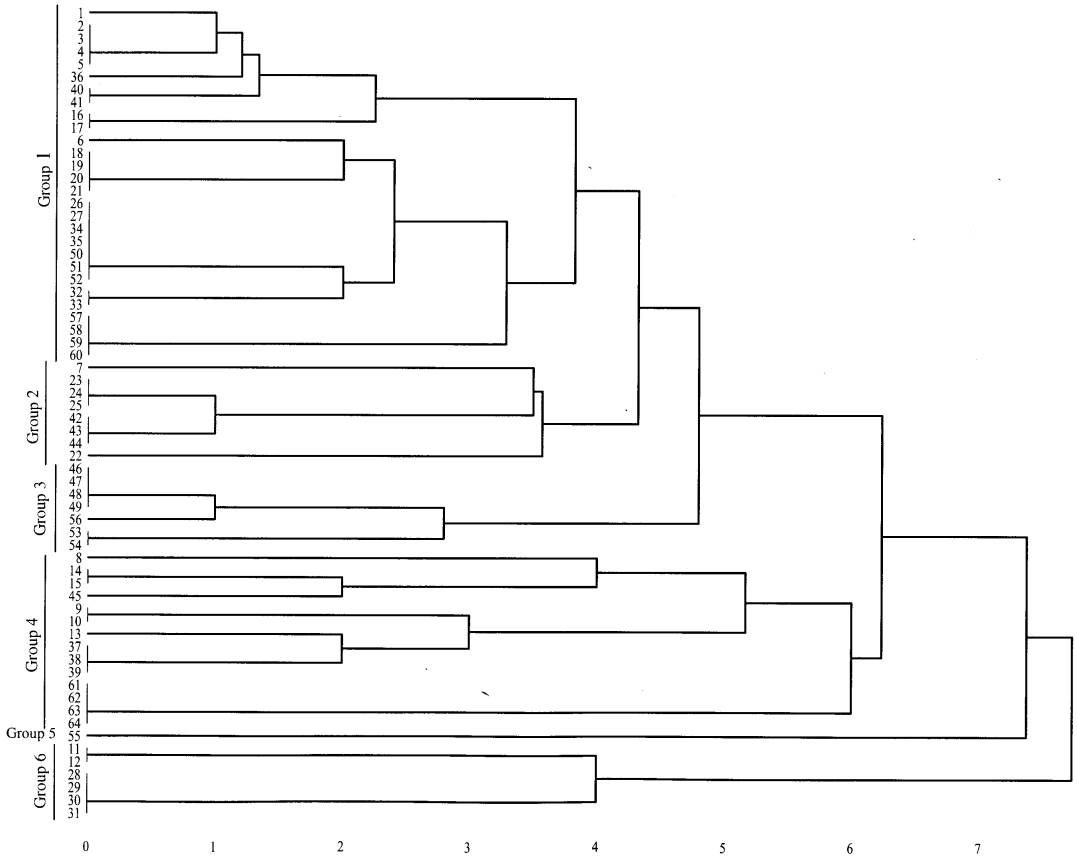

Fig. 2: Dendrogram obtained from the selected 23 morphological parameters, UPGMA method with Squared Euclidean distance. Accessions are indicated with numbers from 1 to 64.
Sl. 2: Dendrogram, napravljen na osnovi 23 izbranih morfoloških parametrov in metode UPGMA s kvadrirano Evklidovo distanco. Oljke so označene s številkami od 1 do 64.

Tab. 3: Morphological description of main olive varieties.
Tab. 3: Morfološki opis glavnih oljčnih sort.

Potential variety	Main morphological characteristics			
	Leaf	**Inflorescence**	**Fruit**	**Stone**
Bjelica	Shape: elliptic-lanceolate Curvature: flat	Number of flowers: scarce	Shape: oval and symmetrical Max diameter: central Ripeness start: uniform	Shape: elliptic Max diameter: central Shape at apex: rounded Shape of base: rounded Surface: rugose
Buža	Shape: elliptic-lanceolate Curvature: flat	Number of flowers: scarce	Shape: spherical and symmetrical Max diameter: central Ripeness start: uniform	Shape: oval Max diameter: central Shape at apex: rounded Shape of base: rounded Surface: scabrous
Duga (buža)	Shape: elliptic-lanceolate Curvature: flat	Number of flowers: scarce	Shape: oval and weakly asymmetrical Max diameter: central Ripeness start: from apex	Shape: oval Max diameter: central Shape at apex: pointed Shape of base: rounded Surface: rugose
Črna (buža, karbonera, domaća, morgaca)	Shape: elliptic-lanceolate Curvature: flat	Number of flowers: scarce	Shape: oval and symmetrical Max diameter: central Ripeness start: uniform	Shape: oval Max diameter: central Shape at apex: rounded Shape of base: pointed Surface: rugose
Črnica	Shape: elliptic-lanceolate Curvature: flat	Number of flowers: scarce	Shape: oval and symmetrical Max diameter: central Ripeness start: from base	Shape: oval Max diameter: towards apex Shape at apex: rounded Shape of base: rounded Surface: scabrous
Karbonera (crnica)	Shape: elliptic-lanceolate Curvature: flat	Number of flowers: scarce	Shape: oval and symmetrical Max diameter: central Ripeness start: uniform	Shape: oval Max diameter: central Shape at apex: rounded Shape of base: rounded Surface: rugose
Drobna	Shape: elliptic-lanceolate Curvature: flat	Number of flowers: scarce	Shape: spherical and symmetrical Max diameter: central Ripeness start: from apex	Shape: spherical Max diameter: central Shape at apex: rounded Shape of base: rounded Surface: scabrous
Karbonaca	Shape: elliptic-lanceolate Curvature: flat	Number of flowers: scarce	Shape: oval and symmetrical Max diameter: central Ripeness start: from apex	Shape: oval Max diameter: central Shape at apex: rounded Shape of base: rounded Surface: scabrous
Moražo	Shape: elliptic Curvature: flat	Number of flowers: scarce	Shape: spherical and symmetrical Max diameter: central Ripeness start: uniform	Shape: spherical Max diameter: central Shape at apex: rounded Shape of base: rounded Surface: rugose
Bilica	Shape: elliptic-lanceolate Curvature: flat	Number of flowers: scarce	Shape: oval and symmetrical Max diameter: central Ripeness start: from base	Shape: elliptic Max diameter: towards apex Shape at apex: rounded Shape of base: rounded Surface: scabrous
Belica	Shape: elliptic-lanceolate Curvature: flat	Number of flowers: scarce	Shape: oval and symmetrical Max diameter: central Ripeness start: from base	Shape: oval Max diameter: central Shape at apex: rounded Shape of base: rounded Surface: rugose
Rosinjola	Shape: elliptic Curvature: flat	Number of flowers: scarce	Shape: oval and symmetrical Max diameter: central Ripeness start: uniform	Shape: elliptic Max diameter: towards apex Shape at apex: rounded Shape of base: pointed Surface: scabrous
Plominka	Shape: elliptic-lanceolate Curvature: flat	Number of flowers: scarce	Shape: spherical and symmetrical Max diameter: central Ripeness start: from apex	Shape: oval Max diameter: central Shape at apex: rounded Shape of base: pointed Surface: rugose
Istarska bjelica (bjankera)	Shape: elliptic-lanceolate Curvature: flat and helicoidal	Number of flowers: scarce	Shape: spherical and symmetrical Max diameter: central Ripeness start: uniform	Shape: elliptic Max diameter: central Shape at apex: rounded Shape of base: rounded Surface: rugose

CONCLUSIONS

The carried out research revealed significant biological diversity of olive varieties in Istrian County. The obtained results indicate their large biological and economic potential. Our classification and description constitute the basic elements for the preservation of old olive varieties as important national biological heritage. Further morphological description, confirmed by molecular investigations and additional chemical analyses of oil, will contribute to a better management of genetic resources as well as to registration of founded varieties in national and international databases.

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IDENTIFIKACIJA IN OZNAČBA AVTOHTONIH SORT OLJK V HRVAŠKI ISTRI

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POVZETEK

Na Istrskem polotoku gojijo različne sorte oljk. Z namenom, da se odpravi zmeda pri imenovanju olj̆nih sort v hrvaški Istri, je bila opravljena temeljita inventarizacija in identifikacija teh sort, in sicer v okviru dolgoročnega raziskovalnega projekta, ki se osredotoča na ohranjanje in valorizacijo avtohtonih sort oljk. Avtorji so v zadnjih treh letih napravili morfološki opis 64 oljk in zbrane podatke uporabili v postopku grozdičaste analize. Vzorce so zbrali v 6 potencialnih sortnih skupinah z najmanj 14 različnimi sortami. Nadaljnje raziskave, vključno z morfološkimi in genetskimi analizami, bodo poglobile vpogled v biološko bogastvo oljk, ki doslej še ni bilo raziskano.

Ključne besede: oljka, avtohtone sorte, morfološke značilnosti

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VPLIV NEKATERIH TEHNOLOŠKIH PARAMETROV NA KAKOVOST PRIDELANEGA ŽAJBLJA *(SALVIA OFFICINALIS* L.)

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IZVLEČEK

Na laboratorijskem polju Biotehniške fakultete v Ljubljani smo v obdobju 1999–2001 preučevali vpliv tehnoloških parametrov (gnojenje z dušikom, rok žetve, požetvena obdelava) na količino in kakovost pridelanega žajblja, ki smo jo opredelili z vsebnostjo eteričnega olja in ursolne kisline v žajbljevih listih. Raziskava je pokazala, da gnojenje z dušikom v drugem letu ni vplivalo na količino in kakovost pridelka, zato le-to ni upravičeno. V tretjem letu je bil zabeležen pozitiven vpliv gnojenja z dušikom na višino pridelka. Čas žetve je značilno vplival na višino pridelka šele v tretjem letu, na kakovost žajblja pa v obeh letih. Vsebnost eteričnega olja in ursolne kisline sta bila v času zorenja semen višja kot v času cvetenja rastlin. Požetvena obdelava na kakovost droge ni imela vpliva. Med drogo, ki smo jo takoj odpeljali v sušilnico, in tisto, ki je ostala na polju še pet dni, razlik v merjenih parametrih kakovosti ni bilo.

Ključne besede: žajbelj, *Salvia officinalis*, eterična olja, gnojenje, čas žetve, požetvena obdelava

INFLUSSO DI ALCUNI PARAMETRI TECNOLOGICI SULLA QUALITÀ DELLA SALVIA COLTIVATA *(SALVIA OFFICINALIS* L.)

SINTESI

Negli anni 1999-2001 le autrici hanno studiato l'influsso di alcuni parametri tecnologici (concimazione con azoto, tempo di mietitura, lavorazione del raccolto) sulla quantità e sulla qualità della salvia coltivata, quest'ultima determinata in base al contenuto di olio eterico e acido ursolico nelle foglie di salvia. La ricerca ha evidenziato che la concimazione con azoto nel secondo anno non ha avuto effetti su quantità e qualità del raccolto. Durante il terzo anno è stato invece registrato un influsso positivo della concimazione con azoto sulla quantità del raccolto. Il tempo di mietitura ha influenzato la quantità del raccolto appena al terzo anno, mentre l'influenza sulla qualità si è registrata in entrambe le annate. Il contenuto di olio eletico e di acido ursolico sono risultati maggiori durante il periodo di maturazione dei semi che non nel periodo di fioritura delle piante. La lavorazione del raccolto non ha avuto effetti sulla qualità della droga. Tra la droga portata direttamente nell'essicatoio e quella lasciata sul campo per altri cinque giorni non sono state registrate differenze nei parametri di qualità.

Parole chiave: salvia, *Salvia officinalis*, olio eterico, concimazione, tempo di mietitura, lavorazione del raccolto

UVOD

Domovine žajblja so Sredozemlje, Balkan in Mala Azija, kjer raste samoniklo na sončnih in apnenčastih pobočjih do nadmorske višine 1000 m. Pri nas je razširjen predvsem na JZ delu države, znana so rastišča na kraškem območju v okolici Kozine in Petrinj, posamezna rastišča manjšega obsega pa najdemo tudi drugod (Baričevič, 1996; Jogan *et al.*, 2001).

Žajbelj *(Salvia officinalis* L.) je polgrm, pogosto uporabljen v kulinariki, tako svež kot suh, znan pa je tudi kot zdravilna rastlina, predvsem kot vir eteričnega olja *(Salviae aetheroleum);* posušeni listi vsebujejo 1–2,5% eteričnega olja. Po določilih Evropske farmakopeje (Ph. Eur. IV, 2002) je zahtevana vsebnost eteričnega olja v žajbljevih listih vsaj 1,5%. Poleg eteričnega olja, ki deluje antiseptično, so med aktivnimi komponentami žajblja posebno pomembni še diterpenoidi, triterpenoidi, flavonoidi in tanini (Baričevič & Bartol, 2000). Med triterpeni, ki jih najdemo v žajblju, ima zelo pomembno vlogo ursolna kislina. Raziskave so potrdile njeno protitumorno, protivnetno, protivirusno in hepatoprotektivno delovanje (Hsu *et al.*, 1997; Baričevič & Bartol, 2000; Baričevič *et al.*, 2001).

Zaradi vse večjega povpraševanja farmacevtske, kemične in živilske industrije po drogi žajblja *(Salviae folium)* zavzema le-ta vse pomembnejšo vlogo na svetovnem trgu. Omenjenim porabnikom, od katerih se brezpogojno zahteva kakovost, učinkovitost in varnost zdravilnih pripravkov, odkup nabranih samoraslih zdravilnih rastlin vse pogosteje ne ustreza, predvsem z vidika zagotavljanja zadostnih količin kakovostne droge. Iz dežel, ki izvažajo surovine, je preskrba namreč neredna, neprimerne kakovosti, cene pa se nenačrtno dvigujejo (Baričevič, 1996).

Pridelovanje žajblja ima zaradi zgoraj navedenih dejstev v zadnjem času vse pomembnejšo vlogo. Pridelovalec lahko na trg ponudi želene količine kakovostne droge, ki jo zagotovi s primerno tehnologijo pridelave in požetvene obdelave. Številne raziskave so pokazale, da sta pridelek in vsebnost eteričnega olja odvisna od rastišča (Santos-Gomes & Fernandes-Frreira, 2001), kultivarja (Gurbuz *et al.*, 1999; Lenzi *et al.*, 2003), gnojenja z dušikom (Dambrauskiene *et al.*, 2001), časa žetve in s tem povezanega razvojnega stadija rastline ob žetvi (Santos-Gomes & Fernandes-Frreira, 2001; Zutic *et al.*, 2003) ter požetvene obdelave (Böttcher & Günther, 1999; Böttcher *et al.*, 2002).

Vendar tudi pridelovanje pomeni določeno stopnjo tveganja. Tudi v pridelanih rastlinah lahko zasledimo ostanke kemičnih sredstev za varstvo rastlin, težkih kovin ali drugih toksičnih spojin. Tem težavam se lahko izognemo s pravilno izbiro tal, ustreznim gnojenjem in pravilno oskrbo posevka rastlin. Kot so zapisali Zuticeva *et al.* (2003), je prednost pridelovanja žajblja pred nabiranjem v naravi tudi v tem, da ga lahko žanjemo dvakrat, prvič v času zorenja semen, drugič pa okoli 70 dni po prvi žetvi. S tem sta zagotovljeni kakovost in regeneracija rastline v tolikšni meri, da le-ta lahko uspešno prezimi.

Cilj naše raziskave je bil preučiti vpliv gnojenja z dušikom, časa žetve in požetvene obdelave na količino in kakovost pridelanega žajblja. Želeli smo ugotoviti, kolikšna količina dodanega dušika je za pridelovanje žajblja z vidika zagotavljanja želenih količin kakovostne droge najbolj primerna, seveda pa tudi najbolj ekonomična. Zanimal nas je optimalen čas žetve oziroma razvojni stadij rastlin, v katerem požanjemo žajbelj z najvišjo vsebnostjo eteričnega olja in ursolne kisline, ter kako požetvena obdelava vpliva na kakovost žajblja.

MATERIAL IN METODE

Poljski poskus je potekal na laboratorijskem polju Biotehniške fakultete v Ljubljani v letih 1999, 2000 in 2001. Analiza tal je pokazala, da so tla psevdoglejna (pH = 7,2; org. snov = 3,6%; teksturni razred meljasta ilovica) ter srednje preskrbljena s fosforjem (7,2 mg P_2O_5/100 g tal) in kalijem (18,7 mg K_2O/100 g tal). Sadike žajblja za poljski poskus so bile vzgojene v rastlinjaku iz semena, ki je hranjeno v Genski banki za zdravilne in aromatične rastline pri Biotehniški fakulteti Univerze v Ljubljani, Oddelek za agronomijo.

Poljski poskus smo zasnovali junija 1999 kot bločni poskus v štirih ponovitvah. Posamezne parcele so bile velike 10 m^2. Rastline smo sadili na medvrstno razdaljo 70 cm, razdalja med rastlinami v vrsti je bila 40 cm, med parcelami pa 90 cm. Med rastjo je bil poskus redno oskrbovan z okopavanjem in mehanskim odstranjevanjem plevelov.

Rastline smo v letih 2000 in 2001 dognojevali s tekočim dušičnim gnojilom (Micro Cristal). Tretjina parcel je bila namenjena kontroli, rastline na teh parcelah niso bile gnojene, tretjina rastlin je bila gnojena s 30 kg N/ha v enkratnem odmerku, tretjina rastlin pa z 81 kg N/ha v trikratnem odmerku po 27 kg N/ha.

Prva žetev (prva polovica rastlin) je bila opravljena v času polnega cvetenja rastlin, druga (druga polovica rastlin) pa v času zorenja semen. Rastline smo želi ročno, s srpom, po žetvi in sušenju v sušilniku pa ovrednotili višino pridelka. V okviru posamezne žetve smo pri prvi polovici požetih rastlin upoštevali načela dobre agronomske prakse, kar pomeni, da smo požeto drogo takoj po žetvi odpeljali v sušilnico, požet žajbelj z druge polovice poskusnih površin pa smo na polju pustili še pet dni ter ga šele nato odpeljali na sušenje v sušilnico.

Pri posušenih rastlinah smo za laboratorijske analize od stebel ločili liste in slednje shranili v papirnate vrečke. Količino eteričnega olja v posameznem vzorcu smo določali po postopku, ki ga predpisuje Evropska farmakopeja (Ph. Eur. IV, 2002). Vsebnost ursolne kisline v metanolnih izvlečkih listov žajblja smo določili z vi-

sokoločljivostno tekočinsko kromatografijo (HPLC), kot je opisano v prispevku Baričevič *et al.* (2001).

Rezultate poskusa smo statistično ovrednotili z metodo analize variance za slučajne bloke (ANOVA; Statgraphics).

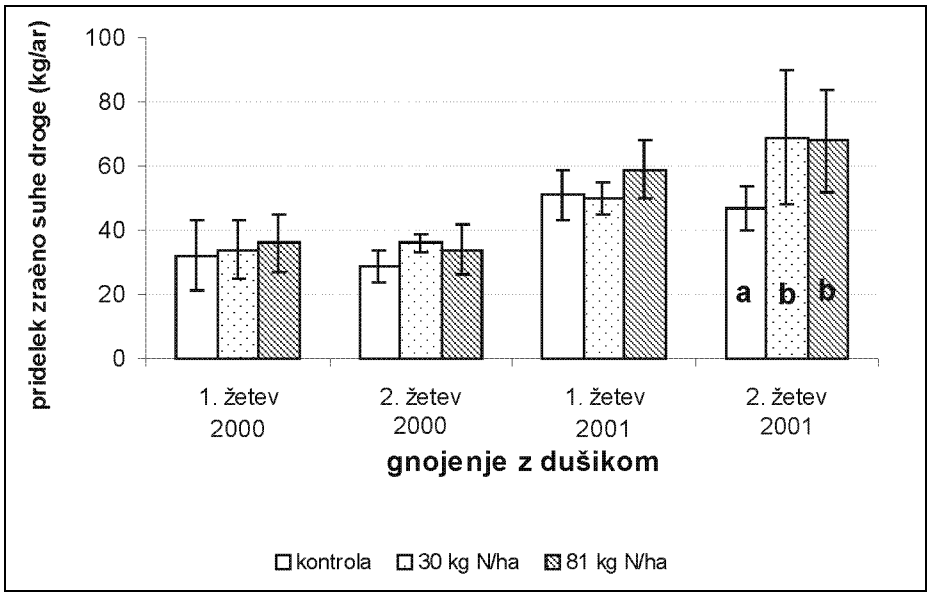
REZULTATI IN RAZPRAVA

V letu 2000, drugi rastni sezoni, gnojenje z dušikom in čas žetve na količino pridelanega žajblja nista značilno vplivala. Masa zračno suhe droge se je gibala v povprečju okoli 34 kg/ar (Sl. 1). Ob prvi žetvi v tretji rastni sezoni (2001) prav tako nismo zabeležili razlik v količini pridelanih listov žajblja med kontrolo in različno gnojenimi parcelami. Pri drugi žetvi pa se je pokazalo, da gnojenje z dušikom pozitivno vpliva na pridelek zračno suhe droge. Masa zračno suhe droge pri rastlinah, ki niso bile gnojene z dušikom, je bila značilno nižja (47,5 kg/ar) v primerjavi z rastlinami z gnojenih parcel (68,3 kg/ar), količina dodanega dušika na pridelek ni imela vpliva. Torej lahko rečemo, da je ekonomsko upravičeno le enkratno gnojenje s 30 kg N/ha. Poljski poskus Dambrauskieneja *et al.* (2001) je pokazal veliko odzivnost rastlin žajblja na gnojenje z dušikom. S povečevanjem odmerka čistega dušika se je povečeval tudi pridelek žajblja, vse do 90 kg N/ha. Eden izmed razlogov za razlike med rezultati naše in zgoraj omenjene raziskave je zagotovo starost rastlin; pri nas se je namreč v tretjem letu ob drugi žetvi pokazala odzivnost rastlin na gnojenje z dušikom. Glede na to, da so Dambrauskiene *et al.* (2001) poskuse opravljali v štiriletnem nasadu, lahko predvidevamo, da bi se odzivnost rastlin našega nasada na gnojenje z dušikom v četrtem letu lahko povečala. Razlog pa je zagotovo lahko tudi izbran genotip. Številni viri namreč navajajo veliko odvisnost odzivnosti rastline od dušičnega gnojenja z genotipom (Gurbuz *et al.*, 1999; Lenzi *et al.*, 2003).

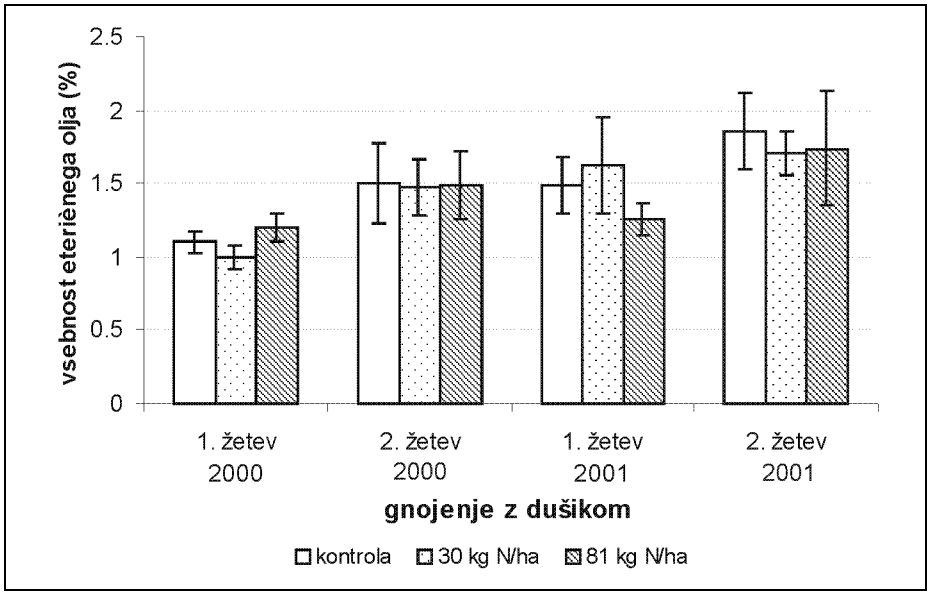
Vpliv časa žetve na višino pridelka se je, kot pri vplivu gnojenja z dušikom, pokazal šele v tretjem letu, v drugem letu razlik v višini pridelka glede na čas žetve namreč nismo zabeležili. Pridelek žajblja je bil ob drugi žetvi tretje rastne sezone (v času zorenja semen) za 19 kg/ar večji kot ob prvi žetvi (v času polnega cvetenja). Podobno je pokazala tudi raziskava, ki so jo opravili Zuticeva *et al.* (2003). Pridelek žajblja v njihovem poljskem poskusu je bil značilno največji ob žetvi v času zorenja semen.

Za žajbelj je znano, da je pridelek največji v tretji in četrti rastni sezoni (Baričevič, 1996). To se je pokazalo tudi v našem poskusu; med obravnavanima letoma so se namreč pokazale statistično značilne razlike v višini pridelka. Pridelek listov žajblja je bil v tretjem letu (57 kg/ar) kar za 60% večji v primerjavi z drugim letom (34 kg/ar).

Gnojenje z dušikom v nobenem letu ni imelo značilnega vpliva na kakovost pridelane droge, vsebnost eteričnega olja in ursolne kisline v žajbljevih listih. Raziskovalna skupina Dambrauskieneja *et al.* (2001) je v že zgoraj omenjenem poskusu dobila enake rezultate kot naša skupina, namreč da gnojenje z dušikom na vsebnost eteričnega olja ne vpliva.

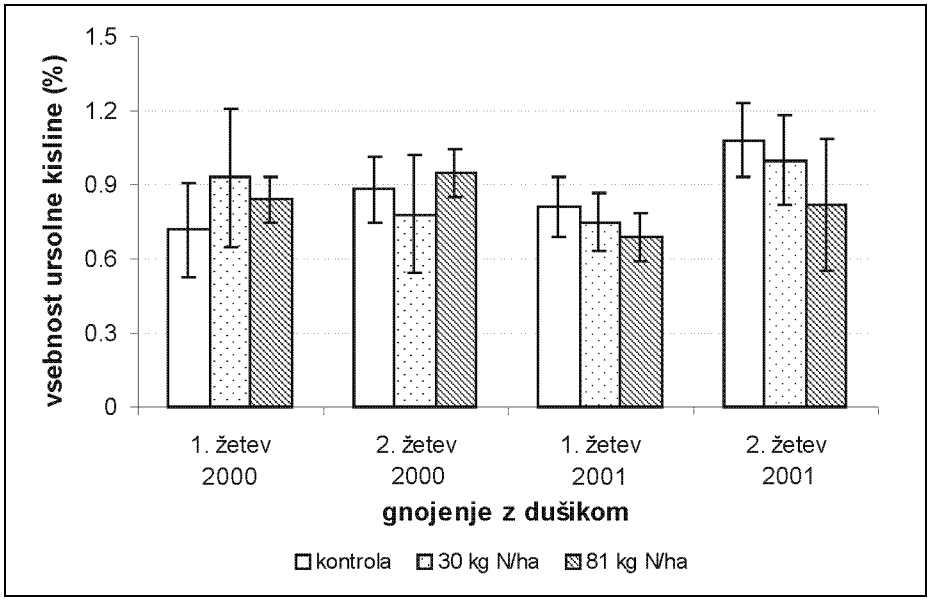


Sl. 1: Pridelek zračno suhih listov žajblja v odvisnosti od gnojenja z dušikom.
Fig. 1: The yield of dry sage leaves as influenced by nitrogen fertilisation.



Sl. 2: Vsebnost eteričnega olja v listih žajblja v odvisnosti od gnojenja z dušikom.
Fig. 2: Essential oil content in sage leaves as influenced by nitrogen fertilisation.

Vsebnost eteričnega olja v drogi pa se je značilno razlikovala v odvisnosti od časa žetve oziroma razvojne faze rastline ob žetvi (Sl. 2). V drugem letu je bila vsebnost eteričnega olja ob prvi žetvi 1,3%, ob drugi pa 1,5%, kar pomeni, da je bila droga šele ob drugi žetvi dovolj kakovostna glede na določila Evropske farmakopeje (najmanj 1,5%) (Ph. Eur. IV, 2002). V tretjem letu je koncentracija eteričnega olja že ob prvi žetvi znašala 1,5%, do druge žetve pa se je še značilno povečala, in sicer na 1,8%. Vsebnost eteričnega olja je bila torej v obeh letih večja ob drugi žetvi, ko so bile rastline v razvojni fazi zorenja semen. Do takšnih rezultatov so prišli v teku svoje raziskave tudi Zuticeva *et al.* (2003), ki so ugotovili, da v odvisnosti od razvojne faze rastline obstajajo tudi razlike v kemijski strukturi eteričnega olja. Enako velja tudi za izsledke raziskave Santos-Gomesove & Fernandes-Ferreiraa (2001).



Sl. 3: Vsebnost ursolne kisline v listih žajblja v odvisnosti od gnojenja z dušikom.
Fig. 3: Ursolic acid content in sage leaves as influenced by nitrogen fertilisation.

Razlike v vsebnosti ursolne kisline v žajbljevih listih ob različnih terminih žetve smo zabeležili šele v tretjem letu; delež ursolne kisline se je ob drugi žetvi, v času zorenja semen, značilno povečal z 0,81% na 1,03% (Sl. 3). V drugem letu razlik med drogo, požeto ob različnih terminih, nismo zabeležili; v povprečju je bilo v drogi 0,85% ursolne kisline.

Požetvena obdelava v nobenem izmed obravnavanih let ni značilno vplivala na kakovost žajblja, vsebnost eteričnega olja in koncentracijo ursolne kisline. Za visoko vsebnost eteričnega olja in ursolne kisline v vzorcih, ki smo jih pred sušenjem v sušilniku proti načelom dobre agronomske prakse še pet dni po žetvi pustili na polju, je po vsej verjetnosti krivo vreme, saj je bilo v dnevih po žetvi zelo toplo in suho, brez padavin. Takšne razmere so bile zelo podobne tistim v sušilnici; omogočile so hitro sušenje požete droge, zato se kakovost žajblja, ki je ostal po žetvi na polju, tako ni znižala.

ZAKLJUČEK

Gnojenje žajblja z dušikom se je v drugem letu izkazalo kot neupravičeno tako s stališča zagotavljanja pridelka in kakovosti droge kot z ekonomskega vidika, v tretjem letu pa je višina pridelka upravičila enkratno gnojenje s 30 kg N/ha. Gnojenje žajbljevih nasadov z dušikom je torej upravičeno šele od tretjega leta naprej. Poskus je pokazal, da pri žetvi poleti, ko so rastline že v fazi zorenja semen, dobimo značilno kvalitetnejši žajbelj, ki vsebuje bistveno večjo količino eteričnega olja in ursolne kisline. Pri pridelavi žajblja se torej priporoča žetev v času zorenja semen. Kljub domnevi, da bo kakovost droge pri neprimerni požetveni obdelavi upadla, tega nismo mogli dokazati. Nekajdnevno čakanje požetega žajblja na sušenje na polju v lepem vremenu kakovosti droge torej ne škodi, vendar se pri pridelavi ne gre zanašati na ugodne vremenske razmere.

THE IMPACT OF CERTAIN TECHNOLOGICAL PARAMETERS ON THE QUALITY OF CULTIVATED SAGE *(SALVIA OFFICINALIS* L.)

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SUMMARY

The impact of some technological parameters (nitrogen fertilization, harvest period and postharvest handling) on the quantity and quality of cultivated sage (Salvia officinalis *L.) was studied in Ljubljana in a field experiment during the 1999-2001 periods. Two different quantities of applied nitrogen (30 kg N/ha and 81 kg N/ha) were compared to the control treatment, where no fertilizers were used, and two harvest periods were studied. In each harvest period, postharvest handling was studied, taking half of the harvested yield directly to the drier and leaving the other half in the field for five days. Quality of sage drug was determined as a percentage of essential oil and ursolic acid. Results of the study showed that nitrogen fertilization in the first two production years had no impact on the quantity and quality of the sage drug, and was therefore not justified. In the third production year, it was recorded that nitrogen fertilization had a significant impact on the sage yield, but there were no differences between the tested mineral nitrogen rates (30 kg N/ha and 81 kg N/ha), so 30 kg of N/ha sufficed. Yield of sage was significantly higher (57 kg/ar) in the third production year comparing to the second production year (34 kg/ar), for about 60%. The harvest period had a significant impact on the yield and quantity of ursolic acid in sage drug in the third production year and on the quantity of essential oil in both production years. The essential oil and ursolic acid contents in the third production year were higher in the sage drug that was harvested in the period of seed ripening compared to the sage harvested in bloom (for essential oil for about 20% and for ursolic acid for about 30%). Comparing the drug taken to the drier immediately after harvest with the drug that stayed in the field for five days, no statistical significant differences were found in the measured quality parameters.*

Key words: sage, *Salvia officinalis*, essential oil, fertilization, harvest period, postharvest handling

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izvirni znanstveni članek
prejeto: 2005-05-17

UDK 594.1/.3(497.4 Park Škocjanske jame)

MEHKUŽCI (MOLLUSCA) V PARKU ŠKOCJANSKE JAME

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IZVLEČEK

V Parku Škocjanske jame je bilo na kopnem in v sladki vodi odkritih 93 vrst in podvrst mehkužcev (školjk in polžev). Vrste Orcula dolium dolium, Pagodulina pagodula pagodula, Cochlodina curta, Cochlodina commutata commutata, Macrogastra (Macrogastra) ventricosa ventricosa, Discus (Gonyodiscus) perspectivus, Oxychilus (Oxychilus) draparnaudi draparnaudi, Isognomostoma isognomostomos *so nove na seznamu kopenskih polžev submediteranske regije Slovenije. Vrsti* Cornu aspersum aspersum in Ena montana *imata v parku drugo najdišče, za vrste* Orcula dolium dolium, Isognomostoma isognomostomos *in* Macrogastra ventricosa ventricosa *pa so najdišča v parku edina v celotni submediteranski regiji Slovenije.*

Ključne besede: kopenski polži, sladkovodni polži, sladkovodne školjke, troglobiontski polži, Park Škocjanske jame, Slovenija

MOLLUSCHI (MOLLUSCA) DEL PARCO DELLE GROTTE DI SAN CANZIANO

SINTESI

Nel Parco delle Grotte di San Canziano sono state trovate 93 specie e sottospecie di molluschi, sia terrestri che di acqua dolce. Le specie Orcula dolium dolium, Pagodulina pagodula pagodula, Cochlodina curta, Cochlodina commutata commutata, Macrogastra (Macrogastra) ventricosa ventricosa, Discus (Gonyodiscus) perspectivus, Oxychilus (Oxychilus) draparnaudi draparnaudi *e* Isognomostoma isognomostomos *sono nuove sulla lista delle lumache terrestri della regione submediterranea della Slovenia. Nel Parco sono state rinvenute per la seconda volta in Slovenia le specie* Cornu aspersum aspersum *e* Ena montana*, mentre per le specie* Orcula dolium dolium, Isognomostoma isognomostomos *e* Macrogastra ventricosa ventricosa *si tratta dell'unico sito di ritrovo nell'intera regione submediterranea della Slovenia.*

Parole chiave: lumache terrestri e d'acqua dolce, bivalvi d'acqua dolce, lumache troglobionti, Parco delle Grotte di San Canziano, Slovenia

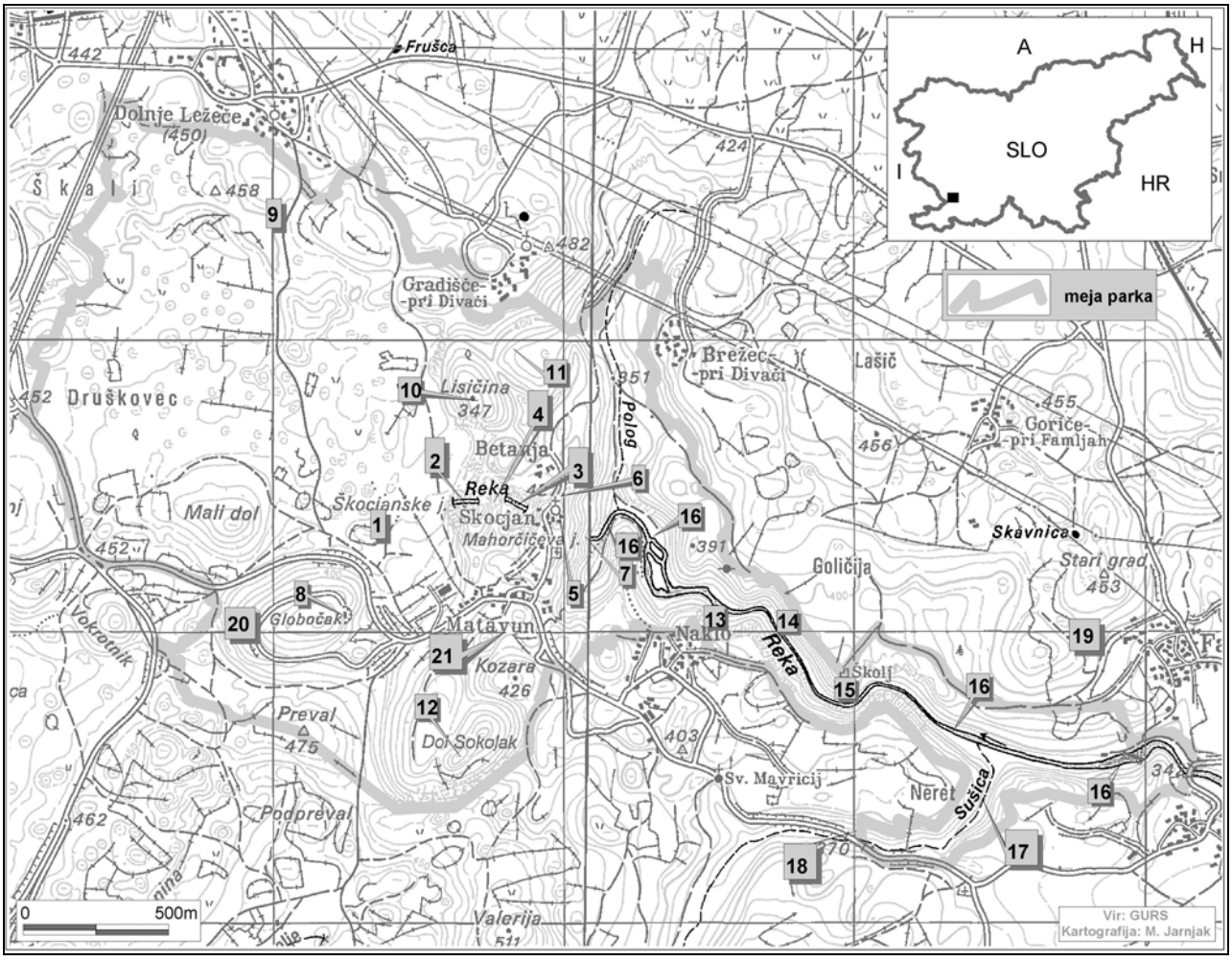
UVOD

V članku predstavljamo rezultate raziskav mehkužcev (Mollusca) v Parku Škocjanske jame, vključno z njihovo vrstno sestavo, razširjenost in pojavljanje na izbranih najdiščih. Malakofavno raziskovanega območja sestavljajo mehkužci iz 2 razredov: polži (Gastropoda) in školjke (Bivalvia). Polži so zastopani s podrazredoma predškrgarjev (Prosobranchia) in pljučarjev (Pulmonata). Zaradi zelo raznolikih habitatov je malakološko zanimivo celotno območje parka. O malakofavni Parka Škocjanske jame obstaja več favnističnih zapisov. Bole (1974) navaja podzemnega polža jamničarja *(Zospeum spelaeum spelaeum)* iz Škocjanskih jam. Kasneje Bole (1981) ter Bole & Slapnik (1998) navajata nekatere vrste kopenskih polžev, ki naseljujejo kraško regijo. V elaboratu, kjer so podani izsledki dvoletnih raziskav flore in favne parka, Slapnik (v Čarni *et al.*, 2002) podaja seznam ugotovljenih vrst mehkužcev. Dve leti kasneje Slapnik (2004) omenja vrste kopenskih polžev, ki se pojavljajo v sondiranih plasteh in v neposredni okolici Viktorjevega spodmola, ki leži 0,5 km severno od skrajnega vzhodnega dela parka.

MATERIAL IN METODE

Območje Parka Škocjanske jame sodi v submediteransko regijo (UTM kvadranta VL15, VL25). V favnistične raziskave mehkužcev smo vključili podatke iz literature in malakološke zbirke Biološkega inštituta ZRC SAZU (MZBI ZRC SAZU) ter rezultate raziskav mehkužcev v najznačilnejših biotopih, kjer smo pričakovali najbogatejšo malakofavno.

Posebna pozornost je bila namenjena raziskavam podzemeljskih vrst polžev v Škocjanskih jamah, ki so potekale v letih 1999 in 2000. Večje kopenske polže



Sl. 1: Najdišča mehkužcev v Parku Škocjanske jame.
Fig. 1: Localities of the molluscs in Škocjan Caves Regional Park.

smo nabirali posamično na površju, pod kamni, na skalah, za lubjem dreves itd. Za drobne vrste smo vzeli vzorce tal na značilnih mestih, največ pod stenami. Vzorci so obsegali 2–4 dm^3 prsti. S selektivnim sejanjem smo izločili polžje hišice in jih ob pomoči literature tudi determinirali (Alzona, 1971; Kerney *et al.*, 1983; Boato *et al.*, 1989; Fechter & Falkner, 1990). Vodne in podzemeljske mehkužce smo nabirali posamično ter s sejanjem jamskih sedimentov in naplavin iz robnih usedlin potoka Sušice in reke Reke. Žive primerke smo narkotizirali in konzervirali v alkoholu, hišice in ostanke hišic pa shranili v fiole.

Nabrani material je shranjen v malakološki zbirki Biološkega inštituta ZRC SAZU v Ljubljani. V rezultate je vključen tudi material, ki sta ga 1999 nabrala dr. Ivan Turk in Janez Dirjevec z Inštituta za arheologijo ZRC SAZU (Slapnik, 2004).

Vzorčna mesta

Vzorčna mesta so prikazana na sliki 1.

1. Škocjanske jame: vzorčevali smo pri ponvicah, v Veliki dvorani, v Tihi dvorani pri električni omarici, pri Gornjem slapu, v Hankejevem kanalu in v Tominčevi dvorani.

2. Velika dolina: vzorčevali smo na severovzhodnem pobočju udornice, nad in pod potjo, ki se spušča proti dnu doline, okrog in v spodmolih jam ter na skalah in stenah na dnu doline.

3. Mala dolina: vzorčevali smo nad potjo pod stenami v severozahodnem pobočju, pod skalami in steno pod Naravnim mostom ter pod stenami nad Tominčevo potjo.

4. Naravni most: vzorčevali smo na skalah in stenah ter v zemeljskih plasteh levo in desno vzdolž poti po Naravnem mostu, pod razgledno točko in na skalah pred železnimi vrati pod Naravnim mostom.

5. Okrog brezna Okroglica: vzorčevali smo po kamnitih ogradah in kraških travnikih okrog udornice.

6. Razgledišče v Škocjanu: vzorčevali smo okrog razgledišča in po pobočju pod njim.

7. Mohorčičeva jama in pobočje ob Mohorčičevi jami: vzorčevali smo v jami in pod stenami nad in pod potjo proti vhodu ter na strmem pobočju nad vhodom.

8. Globočak – udornica: vzorčevali smo v gozdu nad in pod cesto, ki vodi do vhoda in nad betonskim portalom pred predorom.

9. Dolnje Ležeče: vzorčevali smo na travnikih, v grmiščih ter na kamnitih zidovih.

10. Lisična – udornica: vzorčevali smo po skalah in pod stenami po pobočju ter dnu doline.

11. Sapendol – udornica: vzorčevali smo po skalah v gozdu, pod stenami in po pobočju.

12. Sokolak – udornica: vzorčevali smo po skalah in pod stenami po pobočju in dnu doline.

13. Stene soteske reke Reke – stene na levi strani Reke pod Naklom: vzorčevali smo v pobočju pod Naklom ob strugi do nekdanjega mlina in v sami strugi reke.

14. Stene soteske reke Reke – stene na desni strani Reke, zahodno od gradu Školj: vzorčevali smo v pobočju reke ter ob njeni strugi in v njej.

15. Stene soteske reke Reke – stene pod gradom Školj: vzorčevali smo stene pod gradom Školj in na skalah ob gradu.

16. V strugi reke Reke: vzeli smo nanose polžjih hišic in lupin školjk v strugi in na bregovih.

17. Kanjon Sušice, med mostom in izlivom v reko Reko: vzorčevali smo po stenah levo in desno nad potokom od mostu do izliva ter v potoku samem.

18. Cestni ugrez od mostu čez Sušico do cerkvice sv. Mavricija in skalni rob ob cesti do cerkvice sv. Mavricija

19. Viktorjev spodmol, Famlje: Viktorjev spodmol leži v neposredni bližini parka. Vzorčevali smo v gozdu pod robom stene in v spodmolu. V parku ni bila najdena le vrsta *Spelaeodiscus hauffeni*, ki se pojavlja v izkopanih plasteh Viktorjevega spodmola.

20. Jama Škrlica: vzorčevali smo v jami in okrog nje.

21. Kamniti zidovi v Matavunu: vzorčevali smo na kamnitih zidovih in okrog njih.

Tab. 1: Seznam polžev in školjk v Parku Škocjanske jame, v Viktorjevem spodmolu (VS), v Kraškem regijskem parku (KRP), na območju kraškega roba (KR) in v submediteranski regiji (SR) z oznakami arealnih tipov (end. = endemične, evr. = evropske, med. = mediteranske, din. = dinarske, alp.-din. = alpsko-dinarske, alp.-karp. = alpsko-karpatske). (* lupine školjk)

Tab. 1: The list of snails and bivalves in Škocjan Caves Regional Park, at Viktorjev spodmol (VS), in Karst Regional Park (KRP), in the area of Kraški rob (KR), and in the Submediterranean region (SR), with range type denotations (end. = Endemic, evr. = European, med. = Mediterranean, din. = Dinaric, alp.-din. = Alpine-Dinaric, alp.-karp. = Alpine-Carpathian). (* bivalve shells)

Vrsta/Species	VS	KRP	KR	SR	Areal
GASTROPODA					
PROSOBRANCHIA					
Cochlostomatidae					
Cochlostoma (Cochlostoma) septemspirale (Razoumovsky 1789)	+	+	+	+	evr.
Cochlostoma (Cochlostoma) scalarinum (A. & J.B. Villa 1841)		+	+	+	med.
Cochlostoma (Turritus) waldemari (A. J. Wagner 1897)		+		+	din.
Cochlostoma (Turritus) tergestinum (Westerlund 1878)	+	+	+	+	din.
Cochlostoma (Turritus) gracile croaticum (L. Pfeiffer 1870)		+		+	alp.
Pomatiasidae					
Pomatias elegans (O.F. Müller 1774)	+	+	+	+	med.
Aciculidae					
Acicula lineolata banki Boeters, E.Gittenberger & Subai 1993	+	+	+	+	alp.
Platyla gracilis (Clessin 1877)		+	+	+	alp.
Platyla curtii (A.J. Wagner 1912)		+	+	+	med.
Renea spectabilis (Rossmässler 1839)		+	+	+	alp.-din.
Hydrobiidae					
Belgrandiella kuesteri (Boeters 1970)					alp.
PULMONATA					
ARCHAEOPULMONATA					
Carychiidae					
Carychium (Carychium) minimum O.F.Müller 1774		+	+	+	evr.
Carychium (Saraphia) tridentatum (Risso 1826)		+	+	+	evr.
Zospeum spelaeum spelaeum (Rossmässler 1839)				+	end.
BASOMMATOPHORA					
Physidae					
Physa fontinalis (Linnaeus 1758)		+	+		evr.
Physella (Costatella) acuta (Draparnaud 1805)		+	+		med.
Ancylidae					
Ancylus fluviatilis O.F. Müller 1774		+	+		evr.
Lymnaeidae					
Galba truncatula (O. F. Müller 1774)		+	+		evr.
Lymnaea stagnalis (Linnaeus 1758)					evr.
STYLOMMATOPHORA					
Succineidae					
Oxyloma (Oxyloma) elegans elegans (Risso 1826)		+	+	+	evr.
Succinella oblonga (Draparnaud 1801)		+	+	+	evr.
Cochlicopidae					
Cochlicopa lubrica (O. F. Müller 1774)	+	+	+	+	evr.
Cochlicopa lubricella (Rossmaessler 1834)		+	+	+	evr.
Pyramidulidae					
Pyramidula rupestris (Draparnaud 1801)	+	+	+	+	med.
Vertiginidae					
Columella edentula (Draparnaud 1805)		+	+	+	evr.
Truncatellina cylindrica (A. Férussac 1807)		+	+	+	evr.
Truncatellina claustralis (Gredler 1856)	+	+	+	+	evr.
Vertigo (Vertilla) angustior Jeffreys 1830		+		+	evr.
Vertigo (Vertigo) pygmaea (Draparnaud 1801)		+	+	+	evr.
Vertigo pusilla O. F. Müller 1774	+	+	+	+	evr.

Vrsta/Species	VS	KRP	KR	SR	Areal
Orculidae					
Sphyradium doliolum (Bruguiere 1792)	+	+	+	+	evr.
Orcula conica (Rossmässler 1837)	+			+	alp.-din.
Orcula dolium dolium (Draparnaud 1801)					alp.-karp.
Pagodulinidae					
Pagodulina sparsa sparsa (Pilsbry 1924)		+		+	alp.-din.
Pagodulina subdola subdola (Gredler 1856)	+	+	+	+	alp.
Pagodulina pagodula pagodula (Des Moulins 1830)			+		alp.
Pupillidae					
Pupilla (Pupilla) muscorum (Linnaeus 1758)		+	+	+	evr.
Lauriidae					
Lauria (Lauria) cylindracea (Da Costa 1778)		+	+	+	med.
Argnidae					
Agardhiella truncatella (L. Pfeiffer 1841)	+	+	+	+	alp.
Strobilopsidae					
Spelaeodiscus (Spelaeodiscus) hauffeni (F. Schmidt 1855)	+			+	end.
Chondrinidae					
Granaria illyrica (Rossmässler 1835)	+	+	+	+	alp.
Chondrina avenacea avenacea (Bruguiere 1792)	+	+		+	alp.
Vallonidae					
Acanthinula aculeata (O. F. Müller 1774)	+	+	+	+	evr.
Vallonia pulchella (O. F. Müller 1774)	+	+	+	+	evr.
Enidae					
Ena montana (Draparnaud 1801)				+	evr.
Merdigera obscura (O. F. Müller 1774)		+	+	+	evr.
Chondrula tridens tridens (O. F. Müller 1774)	+	+	+	+	evr.
Zebrina detrita (O. F. Müller 1774)	+	+	+	+	evr.
Clausiliidae					
Cochlodina (Cochlodina) laminata grossa (Rossmässler 1835)	+	+	+	+	evr.
Cochlodina (Cochlodina) curta (Rossmässler 1836)		+			din.
Cochlodina (C.) commutata commutata (Rossmässler 1836)		+			alp.
Ruthenica filograna filograna (Rossmässler 1836)	+	+	+	+	evr.
Macrogastra (Pyrostoma) plicatula plicatula (Draparnaud 1801)	+			+	evr.
Macrogastra (Macrogastra) ventricosa ventricosa (Draparnaud 1801)					evr.
Ferussaciidae					
Cecilioides (Cecilioides) acicula (O. F. Müller 1774)	+	+	+	+	evr.
Hohenwartiana hohenwarti (Rossmässler 1839)		+	+	+	med.
Oleacinidae					
Poiretia cornea (Brumati 1838)	+	+	+	+	med.
Testacellidae					
Testacella (Testacella) scutulum G. B. Sowerby 1820		+	+	+	med.
Punctidae					
Punctum (Punctum) pygmaeum (Draparnaud 1801)	+	+	+	+	evr.
Discidae					
Discus (Gonyodiscus) perspectivus (Megerle von Mühlfeldt 1816)	+	+	+		evr.
Vitrinidae					
Semilimax carinthiacus (Westerlund 1886)		?	?	+	evr.
Vitrina pellucida (O. F. Müller 1774)	+	+		+	evr.

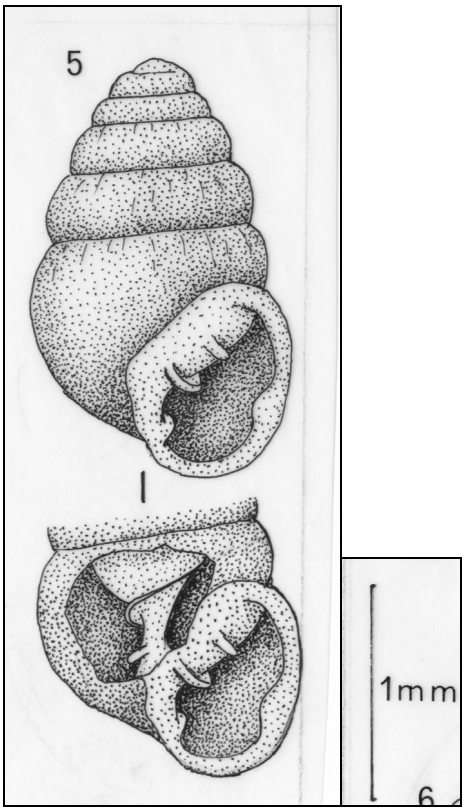
Vrsta/Species	VS	KRP	KR	SR	Areal
Zonitidae					
Vitrea diaphana erjaveci (Brusina 1870)	+	+	+	+	din.
Vitrea subrimata (Reinhardt 1871)	+	+	+	+	alp.
Vitrea crystallina (O.F. Müller 1774)		+		+	evr.
Aegopis verticillus (Lamarck 1822)	+	+	+	+	alp.
Aegopis gemonensis gemonensis (A. Férussac 1832)	+			+	alp.
Aegopinella sp.	+	+	+		evr.
Oxychilus (Oxychilus) cellarius (O. F. Müller 1774)	+	+	+	+	evr.
Oxychilus (Oxychilus) draparnaudi draparnaudi (H. Back 1837)		+	+		med.
Arionidae					
Arion (Mesarion) subfuscus (Draparnaud 1805)		+	+	+	evr.
Limacidae					
Limax cinereoniger Wolf 1803	+	+	+	+	evr.
Limacus flavus (Linnaeus 1758)	+	+	+	+	evr.
Lehmannia marginata (O. F. Müller 1774)		+	+	+	evr.
Agriolimacidae					
Deroceras (Deroceras) laeve (O. F. Müller 1774)		+	+	+	evr.
Bradybaenidae					
Fruticicola fruticum (O.F. Müller 1774)	+	+	+	+	evr.
Hygromiidae					
Trichia (Trichia) hispida (Linnaeus 1758)		+		+	evr.
Petasina (Filicinella) leucozona (C. Pfeiffer 1828)	+			+	alp.
Monachoides incarnatus incarnatus (O.F. Müller 1774)		+	+	+	evr.
Monacha (Monacha) cartusiana (O. F. Müller 1774)	+	+	+	+	med.
Euomphalia strigella strigella (Draparnaud 1801)		+	+	+	evr.
Helicodonta obvoluta obvoluta (O. F. Müller 1774)		+	+	+	evr.
Isognomostoma isognomostomos (Schröter 1784)					alp.-karp.
Helicidae					
Faustina illyrica illyrica (Stabile 1864)	+	+	+	+	alp.-din.
Cepaea (Cepaea) nemoralis nemoralis (Linnaeus 1758)	+	+	+	+	evr.
Cepaea (Austrotachea) vindobonensis (A. Férussac 1821)		+	+	+	evr.
Cornu aspersum aspersum (O.F. Müller 1774)		+	+	+	med.
Helix pomatia Linnaeus 1758	+	+	+	+	evr.
B I V A L V I A					
Sphaeridae					
Musculium (Musculium) lacustre (O.F. Müller 1774)*		+	+		evr.
Pisidium (Pisidium) amnicum (O.F. Müller 1774)		+	+		evr.
Microcondylea compressa (Menke 1830)*					alp.

REZULTATI

Območje Parka Škocjanske jame naseljuje 90 vrst in podvrst polžev ter 3 vrste školjk (Tab. 1, 2). So zelo različnih arealnih tipov (Kerney *et al.*, 1983; Bole & Slapnik, 1998): 52 vrst je z velikim arealom razširjenosti (holarktični, palearktični in evropski v širšem smislu), 15 je alpskih, 12 mediteranskih, 5 dinarskih, 4 so alpsko – dinarske, 2 sta alpsko – karpatski in 2 endemični.

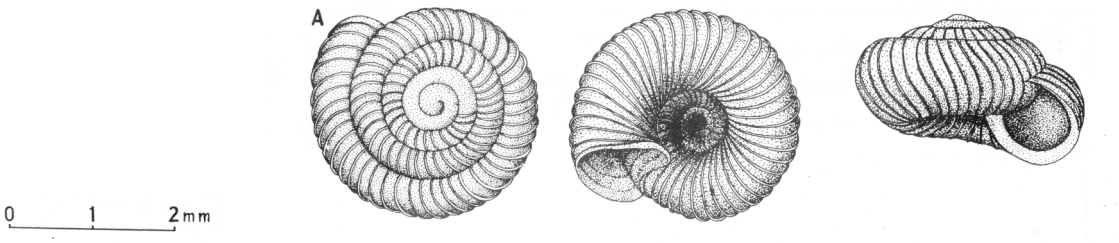
V rodu *Cochlostoma* je najpogostejša vrsta *Cochlostoma septemspirale*, ki je severno dinarska vrsta (Bole, 1976). Poleg nje se v parku redkeje pojavljajo še *C. tergestinum, C. gracile, C. scalarinum* in *C. waldemari.* Simpatrični vrsti *Acicula lineata bankii* in *Platyla gracilis* se v talnem vzorcu okrog Viktorjevega spodmola pojavljata v približno enakem razmerju. V celotnem območju parka pa je *A. lineata bankii* pogostejša. Troglobiontski suhozemski polžki vrste *Zospeum spelaeum spelaeum* (Sl. 2) so bili v Škocjanskih jamah najdeni v jamskem sedimentu na vseh vzorčevanih mestih. Posamezne hišice in polže smo našli v Tihi dvorani pri električni omarici, pri Gornjem slapu in v Hankejevem kanalu. V reki

Reki in potoku Sušica so bile večinoma najdene le hišice vodnih vrst polžev (*Physa fontinalis, Physella (Costatella) acuta, Ancylus fluviatilis, Galba truncatula, Lymnaea stagnalis).* Želodčarka oz. sredozemska roparica *(Poiretia cornea)* iz družine Oleacinidae je v parku značilna vrsta. *Vitrea subrimata* iz družine Zonitidae je splošno razširjena in dominira pred vrsto *V. diaphana erjaveci.* Vrsta *Ena montana* (Sl. 3) je bila najdena na stenah na levi strani soteske reke Reke pod Naklom. *Spelaeodiscus hauffeni* (Sl. 4) iz družine Pupillidae je bil najden v 11. režnju Viktorjevega spodmola. Iz družine ovsark (Chondrinidae) se na apnenih skalah običajno pojavlja *Chondrina avenacea*. Na toplih, prisojnih legah v notranjosti Slovenije in v Primorju živi ilirska sirotica *Granaria illyrica.* Najpogostejša in najbolj razširjena vrsta iz družine Helicidae je *Faustina illyrica illyrica*. Redkejša je *Kosicia intermedia*.



Sl. 2: *Zospeum spelaeum spelaeum****, Postojnska jama. (Risal: J. Bole)***
Fig. 2: *Zospeum spelaeum spelaeum****, Postojna Caves. (Drawn by: J. Bole)***

Sl. 3: *Ena montana****, Park Škocjanske jame. (Foto: R. Slapnik)***
Fig. 3: *Ena montana****, Škocjan Caves Regional Park. (Photo: R. Slapnik)***

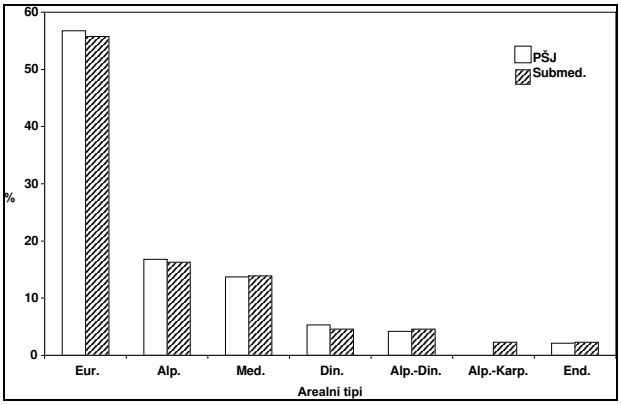


Sl. 4: *Spelaeodiscus hauffeni****. (Risal / Drawn by: J. Bole)***

RAZPRAVA

V jami Škrlici podvrste *Zospeum spelaeum spelaeum* kljub odvzemu večje količine jamskega sedimenta nismo našli. Za vrsto *Ena montana* so stene na levi strani soteske reke Reke pod Naklom njeno drugo najdišče v submediteranski regiji pri nas – za najdiščem v Podgorju pod Slavnikom (coll. MZBI). Od golih polžev smo v okolici Viktorjevega spodmola in v dolini Reke pod gradom Školj našli *Limax cinereoniger* in *Limacus flavus.* Redkeje se pojavljata *Arion subfuscus,* ki ga je našel Wiktor (1996) v kvadrantu VL26, in *Deroceras*

(Deroceras) leave, ki ga je našel Velkovrh (Vavpotič & Velkovrh, 2002) v Ospu (VL 14). Vrsta *Lehmannia marginata* je omenjena za Kraški regijski park (Slapnik, 1996), za Kraški rob (Bole & Slapnik, 1990) in submediteransko regijo Slovenije (Bole & Slapnik, 1998). Večje število ostankov hišic rodu *Limax* in *Lehmannia* je bilo najdenih v večini plasteh Viktorjevega spodmola (Slapnik, 2004). Vrsta *Cornu aspersum* je bila poleg najdišč v parku ugotovljena le še v Ospu, kar je njeno drugo najdišče v submediteranski regiji. Povsod po toplih prisojnih legah najpogosteje najdemo vrste: *Cochlostoma septemspirale, Pomatias elegans, Granaria illyrica, Chondrina avenacea avenacea, Chondrula tridens tridens, Ruthenica filograna filograna, Poiretia cornea, Monachoides incarnatus incarnatus, Faustina illyrica illyrica*. Presenetljivo je, da na izbranih lokalitetah v parku nismo našli podvrste *Delima (Semirugata) bilabiata bilabiata*, ki je dokaj pogosta v submediteranski regiji (Bole & Slapnik, 1998).



Sl. 5: Procentualne vrednosti malakocenoz v Parku Škocjanske jame (PŠJ) in v submediteranski regiji (Submed.) v odvisnosti od arealnih tipov (evr. = evropske, alp. = alpske, med. = mediteranske, din. = dinarske, alp.-din. = alpsko-dinarske, alp.-karp. = alpsko-karpatske, end. = endemične).
Fig. 5: Percentile values of malacocenoses in Škocjan Caves Park (PŠJ) and in the Submediterranean region (Submed.), subject to range types (evr. = European, alp. = Alpine, med. = Mediterranean, din. = Dinaric, alp.-din. = Alpine-Dinaric, alp.-karp. = Alpine-Carpathian, end. = endemic).

Primerjalno so procentualne vrednosti arealnih tipov kopenskih mehkužcev v parku Škocjanske jame zelo podobne vrednostim v submediteranskem območju (Bole & Slapnik, 1998) (Sl. 5). Bole & Slapnik (1998) sta navedla 158 taksonov kopenskih mehkužcev, med katerimi je 77 evropskih vrst, 25 alpskih, 22 mediteranskih, 11 dinarskih, 12 alpsko-dinarskih in 11 endemičnih. V območju Parka Škocjanske jame je bilo najdenih 85 kopenskih mehkužcev, med katerimi je 48 evropskih vrst, 14 alpskih, 11 mediteranskih, 4 dinarske, 4 alpsko-dinarske, 2 alpsko-karpatski in 2 endemični.

Med 93 vrstami mehkužcev, ki živijo v parku, je 8 kopenskih vrst polžev, ki niso navedeni v pregledu kopenskih polžev v submediteranskem območju Slovenije (Bole & Slapnik 1998). Med njimi je 5 vrst *(Pagodulina pagodula pagodula, Cochlodina curta, Cochlodina commutata commutata, Oxychilus (Oxychilus) draparnaudi draparnaudi* in *Discus (Gonyodiscus) perspectives*), ki se posamično pojavljajo tudi zunaj parkovnega območja (Bole & Slapnik, 1990; Slapnik, 1996) in 3 vrste (*Orcula dolium dolium, Macrogastra ventricosa ventricosa* in *Isognomostoma isognomostomos*), za katere je park edino najdišče v submediteranski regiji Slovenije. Vrsti *Cornu aspersum aspersum* in *Ena montana* imata v parku drugo poznano najdišče v submediteranski regiji Slovenije.

ZAHVALA

Raziskave so bile opravljene v sklopu projekta Flora, favna in vegetacija regijskega Parka Škocjanske jame T1-2021-0618-00, ki sta ga finansirala Ministrstvo za šolstvo, znanost in šport in Park Škocjanske jame. Zahvala gre tudi dr. Ivanu Turku in Janezu Dirjevcu, ki sta skrbno izločila polžje hišice in njene ostanke iz izkopanih plasti v Viktorjevem spodmolu ter mi jih izročila v obdelavo. Za nasvete in pomoč pri determinaciji ostankov hišic iz Viktorjevega spodmola se najtopleje zahvaljujem dr. Marii Manueli Giovannelli iz Prirodoslovnega muzeja v Vidmu (Museo Friulano di Storia Naturale). Za tehnično pomoč se zahvaljujem Janji Valentinčič in Marjanu Jarnjaku.

Tab. 2: Najdišča polžev in školjk v Parku Škocjanske jame in v Viktorjevem spodmolu.
Tab. 2: The localities of snails and bivalves in Škocjan Park Regional Park and at Viktorjev spodmol.

Mehkužci/Molluscs	**Najdišča/Localities**																				
Vrste/Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Cochlostoma (Cochlostoma) septemspirale		+	+	+		+	+		+	+	+	+	+		+	+		+	+		
Cochlostoma (Cochlostoma) scalarinum		+	+	+		+															
Cochlostoma (Turritus) waldemari		+																			
Cochlostoma (Turritus) tergestinum		+	+	+		+	+			+	+	+			+						
Cochlostoma (Turritus) gracile croaticum		+	+	+		+															
Pomatias elegans		+	+	+	+	+	+		+	+	+	+	+		+		+	+	+	+	
Acicula lineolata banki		+	+	+	+	+	+		+			+			+			+	+		
Platyla gracilis		+	+	+										+	+		+	+	+		
Platyla curtii		+	+	+	+		+					+	+		+		+	+			
Renea spectabilis				+								+			+				+		
Belgrandiella kuesteri																+	+				
Carychium (Carychium) minimum		+	+	+					+								+				
Carychium (Saraphia) tridentatum		+	+	+									+			+	+				
Zospeum spelaeum spelaeum	+																				
Physa fontinalis																+	+				
Physella (Costatella) acuta																+	+				
Ancylus fluviatilis																+	+				
Galba truncatula																+	+				
Lymnaea stagnalis																+	+				
Oxyloma (Oxyloma) elegans elegans																+					
Succinella oblonga																+					
Cochlicopa lubrica						+													+		
Cochlicopa lubricella		+	+	+																	
Pyramidula rupestris			+	+					+							+			+		
Columella edentula		+	+	+																	
Truncatellina cylindrica						+	+											+			
Truncatellina claustralis					+	+	+		+			+	+		+		+	+	+		
Vertigo (Vertilla) angustior			+																		
Vertigo (Vertigo) pygmaea																	+				
Vertigo pusilla			+	+													+		+		
Sphyradium doliolum			+																+		
Orcula conica			+														+				
Orcula dolium dolium			+														+		+		
Pagodulina sparsa sparsa															+		+				
Pagodulina subdola subdola			+																+		
Pagodulina pagodula pagodula															+		+				
Pupilla (Pupilla) muscorum			+														+				
Lauria (Lauria) cylindracea			+																		
Agardhiella truncatella		+															+		+		
Spelaeodiscus (Spelaeodiscus) hauffeni																			+		
Granaria illyrica		+	+	+	+		+		+									+	+		
Chondrina avenacea avenacea		+	+	+									+					+	+		
Acanthinula aculeata		+	+	+		+			+				+	+					+		
Vallonia pulchella							+										+		+		
Ena montana													+								
Merdigera obscura			+														+				
Chondrula tridens tridens		+	+	+					+				+					+	+		
Zebrina detrita												+									
Cochlodina (Cochlodina) laminata grossa		+	+										+				+				

Mehkužci/Molluscs	**Najdišča/Localities**																				
Vrste/Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Cochlodina (Cochlodina) curta		+	+	+	+								+				+				
Cochlodina (C.) commutata commutata		+	+	+									+				+				
Ruthenica filograna filograna		+	+	+	+	+			+				+				+	+	+		
Macrogastra (Pyrostoma) plicatula plicatula													+				+		+		
Macrogastra (M.) ventricosa ventricosa													+				+		+		
Cecilioides (Cecilioides) acicula			+	+	+		+		+				+				+		+		
Hohenwartiana hohenwarti															+						
Poiretia cornea		+	+	+	+	+	+						+		+		+	+	+		
Testacella (Testacella) scutulum																		+	+		
Punctum (Punctum) pygmaeum		+	+	+					+								+	+	+		
Discus (Gonyodiscus) perspectivus		+	+	+															+		
Semilimax carinthiacus															+						
Vitrina pellucida			+	+					+								+	+			
Vitrea diaphana erjaveci			+														+	+	+		
Vitrea subrimata													+				+		+		
Vitrea crystallina																	+	+			
Aegopis verticillus		+	+	+					+				+				+		+		
Aegopis gemonensis gemonensis																		+	+		
Aegopinella sp		+	+	+									+				+		+		
Oxychilus (Oxychilus) cellarius			+	+					+												
Oxychilus (O.) draparnaudi draparnaudi			+	+					+										+		
Arion (Mesarion) subfuscus															+						
Limax cinereoniger														+					+		
Limacus flavus														+					+		
Lehmannia marginata																	+				
Deroceras (Deroceras) laeve																	+				
Fruticicola fruticum																			+		
Trichia (Trichia) hispida												+	+						+		
Petasina (Filicinella) leucozona												+	+						+		
Monachoides incarnatus incarnatus		+	+	+					+				+		+		+	+	+		
Monacha (Monacha) cartusiana																		+	+		
Euomphalia strigella strigella			+											+							
Helicodonta obvoluta obvoluta																	+		+		
Isognomostoma isognomostomos													+				+				
Faustina illyrica illyrica		+	+	+	+				+										+		
Cepaea (Cepaea) nemoralis nemoralis													+				+				
Cepaea (Austrotachea) vindobonensis									+			+	+	+	+				+		
Cornu aspersum aspersum									+				+		+						
Helix pomatia									+				+	+	+			+	+		
Musculium (Musculium) lacustre																+	+				
Pisidium (Pisidium) amnicum																+	+				
Microcondylaea compressa																+					

THE MOLLUSCS (MOLLUSCA) OF ŠKOCJAN CAVES REGIONAL PARK

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SUMMARY

The entire area of Škocjan Caves is in terms of its malacology exceptionally interesting owing to its highly diverse habitats. The faunistic research, which included the data obtained from literature, field work carried out in 1999–2000, and malacological collections of the Jovan Hadži Institute of Biology functioning within the Scientific Research Centre of the Slovenian Academy of Sciences and Arts, encompassed both terrestrial and freshwater molluscs. The malacofaunistically researched areas consist of snails (Gastropoda), which are represented by the subclasses of Prosobranchia and Pulmonata, and bivalves (Bivalvia).

The area of Škocjan Regional Park is inhabited by 90 snail species and subspecies and 3 bivalve species of various range types: 52 species are known for their large distribution range (Holarctic, Palaearctic and European in a wider sense), 15 are Alpine, 12 Mediterranean, 5 Dinaric, 4 Alpine-Dinaric, 2 Alpine-Carpathian, and 2 endemic. In sunward localities, the following species can be most often found: Cochlostoma septemspirale, Pomatias elegans, Granaria illyrica, Chondrina avenacea avenacea, Chondrula tridens tridens, Ruthenica filograna filograna, Poiretia cornea, Monachoides incarnatus incarnatus *and* Faustina illyrica illyrica. *It is surprising that the species* Delima (Semirugata) bilabiata bilabiata*, which is otherwise fairly common in the Submediterranean region, was not found at the Park's selected localities.*

The recorded species, i.e. Orcula dolium dolium, Pagodulina pagodula pagodula, Cochlodina curta, Cochlodina commutata commutata, Macrogastra (Macrogastra) ventricosa ventricosa, Discus (Gonyodiscus) perspectivus, Oxychilus (Oxychilus) draparnaudi draparnaudi *and* Isognomostoma isognomostomos *are new on the list of terrestrial snails of the Slovene Submediterranean region. As far as the species* Cornu aspersum aspersum *and* Ena montana *are concerned, the Park is their second locality, while for the species* Orcula dolium dolium, Macrogastra ventricosa ventricosa *and* Isognomostoma isognomostomos*, their localities in the Park are their only ones in the entire Submediterranean region of Slovenia.*

Key words: terrestrial and freshwater snails, freshwater bivalves, troglobionts, Škocjan Caves Regional Park, Slovenia

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NOTES ON SPERMATOPHORES IN *CYPHOPHTHALMUS DURICORIUS* JOSEPH (ARACHNIDA: OPILIONES: SIRONIDAE)

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ABSTRACT

The spermatophores in the sironid species Cyphophthalmus duricorius duricorius *(JOSEPH, 1868) are presented. They were found in three females in Slovenia. The spermatophores consist of a bulb-like terminal portion, a tubular, and a basal portion, and are very similar to those in* C. serbicus *(HADŽI, 1973).*

Key words: arachnids, Cyphophthalmi, *Cyphophthalmus duricorius*, Opiliones, Sironidae, spermatophore

ANNOTAZIONI SU SPERMATOFORI DI *CYPHOPHTHALMUS DURICORIUS* JOSEPH (ARACHNIDA: OPILIONES: SIRONIDAE)

SINTESI

L'articolo presenta annotazioni sugli spermatofori di una specie di Sironidi, Cyphophthalmus duricorius duricorius *(JOSEPH, 1868). Gli spermatofori sono stati ritrovati in tre femmine in Slovenia e consistono in una porzione terminale a capsula, una porzione tubulare ed una basale. Sono molto simili a quelli della specie* C. serbicus *(HADŽI, 1973).*

Parole chiave: aracnidi, Cyphophthalmi, *Cyphophthalmus duricorius*, opilionidi, Sironidae, spermatofori

INTRODUCTION

Joseph (1868a) described the species *Cyphophthalmus duricorius* from the Jama pod Predjamskim gradom cave in the Predjama cave system near Postojna, Slovenia. Afterwards he made notice of further localities in the country (Joseph, 1868b, 1881, 1882), citing the species also under "(*Cyphophthalmus*) *Siro duricorius*". This way he showed that his newly described genus *Cyphophthalmus* should be taken under the synonymy of the genus *Siro* LATREILLE, 1796, and this statement was generally accepted, *e.g.* by Hansen & Sørensen (1904), Roewer (1923), Martens (1978). Later on, *Cyphophthalmus duricorius corfuanus* KRATOCHVÍL, 1937 (Kratoctvíl, 1937), *C. d. bythinicus* GRUBER, 1969, and *C. d. yalovensis* GRUBER, 1969 (Gruber, 1969) were described. Recently, the Balkan species were placed in the resurrected genus *Cyphophthalmus* JOSEPH, 1868 (Boyer *et al.*, 2005).

Sperm transfer is indirect in most arachnids, implemented by producing spermatophores or using specially modified palps in spiders (Ruppert & Barnes, 1994). Spermatophores are mostly stalky packages of sperm produced by males and gathered by females. Most harvestmen have a penis and ovipositor, while the role of the male genital organ in Cyphophthalmi has been supposed to take part in spermatophore deposition, therefore named spermatopositor (van der Hammen, 1985). Karaman (2005) noticed the evidence of spermatophores in *C. serbicus* (HADŽI, 1973) and in an undescribed *Cyphophthalmus* species, while Schwendinger & Giribet (2005) noticed the attachment of similar spermatophores to a female gonostome in the stylocellid genus *Stylocellus*, and they are known also in other stylocellids (Giribet, *in lit.*). The spermatophore consists of three parts: a bulb-like terminal portion having an appearance of a perforated compressed ball, a tubular, and a basal portion. The existence of spermatophores has been expected in other *Cyphophthalmus* species. Our scope was to prove the presence of spermatophores in *C. d. duricorius*, which is the type species of the genus, and to make a morphological comparison with those in *C. serbicus* and *Cyphophthalmus* sp.

MATERIAL AND METHODS

During the revision of *C. duricorius* in opilionid collections deposited in the Slovene Museum of Natural History (Ljubljana), about 300 specimens were checked for spermatophores. These were studied using Olympus CH30 microscope, and photographed with the Olympus C 4040 Zoom Digital Camera. The spermatophores were not detached from females and were studied as temporary mounts embedded in glycerol in Bürker-Türk's haemocytometer, illuminated from above. Measurements were taken from photographs considering the measure grid in the haemocytometer photographed at the same magnitude.

RESULTS

In the revised specimens of *C. d. duricorius* from Slovenia, three females with attached spermatophores were recorded (Figs. 1 a-d). In front of the Otoška jama cave near Postojna (UTM code VL37), a female with a spermatophore appeared on May 12th (the determination number TN 46/2004), while in Strmec (UM94), such female was collected on July 10th (TN 907/1998), and in Vitomarci (WM75) on July 3rd (TN 795/2002). The spermatophore is shaped like in *C. serbicus*, and an abundant amorphous mass (Figs. 1a, c), secreted mutually of ovipositor sticky glands (Karaman, 2005), is present. The frontal bulb portion is oval in shape measuring about 250–320 μm (257x314 μm, Fig. 1e); the tube is about 420–450 μm long. The basal part was not studied. In one case, the bulb portion has a short stalk-like protrusion (Fig. 1d), and globular contents are visible.

DISCUSSION

Karaman (2005) noticed that spermatophores are rarely to be found in *Cyphophthalmus*; in over 1000 specimens collected, he found only two females with spermatophores attached. The author of the present paper remembers a few cases of spermatophore removal from females while cleaning them for taxonomical studies. As the spermatophores resemble rather a waste plant material, introduced into the genital opening by accident, than an animal product, they have been very likely overlooked also by other opilionologists. As expected, the spermatophores in *C. d. duricorius* are of similar shape as in *C. serbicus*, but they are slightly bigger. At the moment, there is no reasonable explanation for this. Karaman (2005) exposed that there are more open than answered questions as for mating and sperm transfer in *Cyphophthalmus*. Most relevant data can be provided by direct observation.

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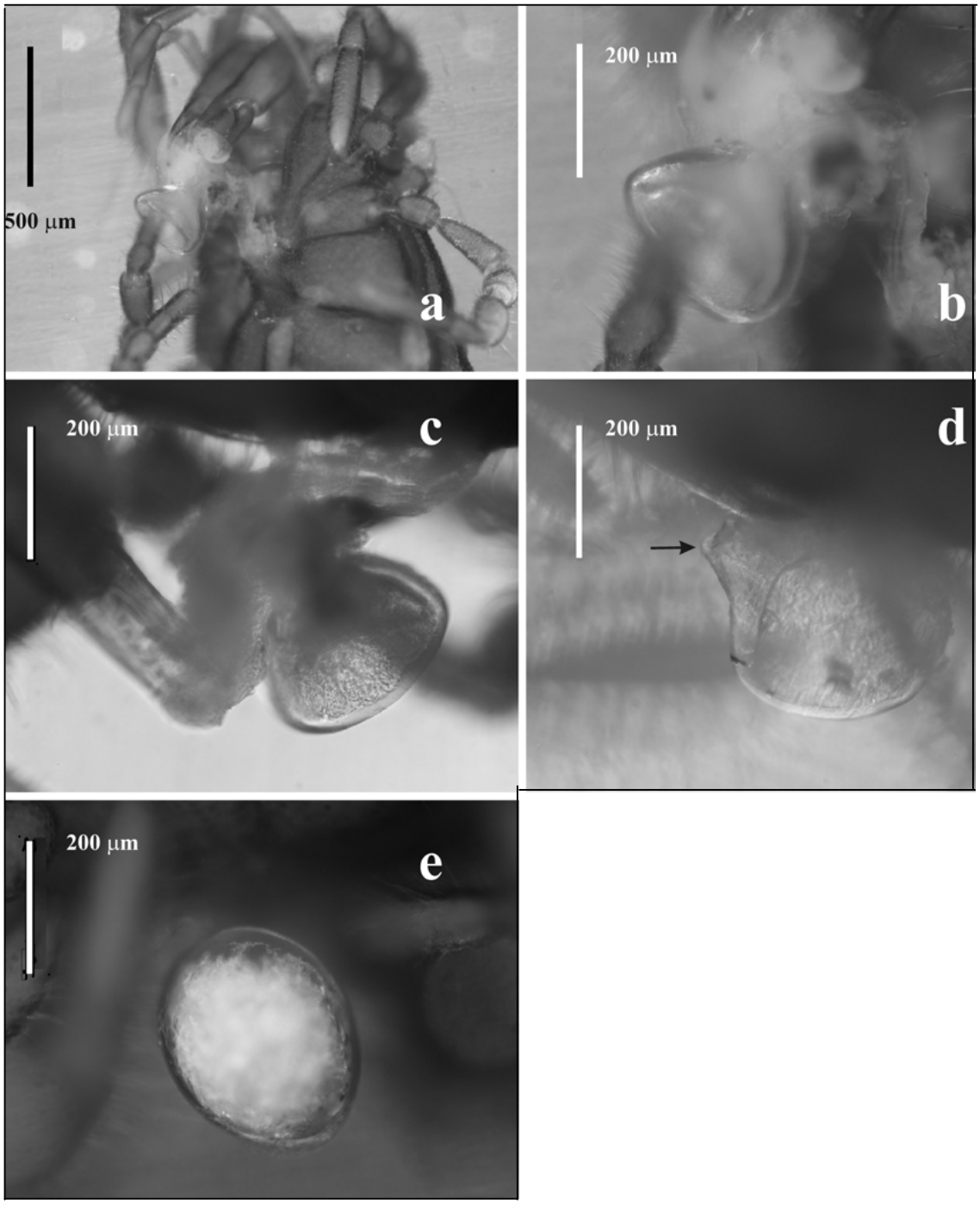

Fig. 1: *Cyphophthalmus duricorius duricorius* ***JOSEPH, 1868. (a) female with a white amorphous sticky mass on chelicerae, and an attached spermatophore; (b) the same female with the amorphous mass and spermatophore enlarged; (c) the side view of the amorphous mass attached to chelicerae, and the spermatophore; (d) cut-off or damaged (?) terminal bulb-like portion of the spermatophore (arrow); (e) terminal portion with the contents of globular appearance, probably encapsulated sperm.***

Sl. 1: *Cyphophthalmus duricorius duricorius* ***JOSEPH, 1968. (a) samica z belo amorfno lepljivo snovjo na helicerah in s pritrjenim spermatoforom; (b) ista samica z amorfno snovjo in spermatoforom pri večji povečavi; (c) pogled od strani na amorfno snov, pritrjeno na helicere, in spermatofor; (d) odrezan ali poškodovan (?) končni, zaobljeni del spermatofora (puščica); (e) končni, zaobljeni del spermatofora s kroglasto (globularno) vsebino, verjetno paketki sperme.***

SPERMATOFORI PRI *CYPHOPHTHALMUS DURICORIUS* JOSEPH (ARACHNIDA: OPILIONES: SIRONIDAE)

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POVZETEK

Avtor je med revizijo družine Sironidae v Sloveniji našel na treh samicah vrste Cyphophthalmus duricorius *JOSEPH, 1868, ki je tipska vrsta rodu, pritrjene spermatofore. Sestojijo iz treh delov: končnega zaobljenega dela, podobnega preluknjani stisnjeni žogi, cevastega ter osnovnega dela. Ovalni končni del meri okrog 250–320 µm v premeru, cevasti del je okrog 420–450 µm dolg, medtem ko osnovni del ni bil izmerjen, ker spermatofori niso bili odstranjeni s samic. Spermatofori* C. duricorius *duricorius so zelo podobni tistim pri* C. serbicus *HADŽI, 1973, ki so prvi opisani spermatofori med Cyphophthalmi.*

Ključne besede: Cyphophthalmi, *Cyphophthalmus duricorius*, Opiliones, pajkovci, Sironidae, spermatofor

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ILOVA GORA AND ČUŠPERK BAUXITE DEPOSITS

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ABSTRACT

Ilova Gora and Čušperk bauxite deposits comprise Gradišče, Mali vrh (552 m), Šopeh and Čušperk (SE Slovenia) occurrences. Bauxite bodies are interbedded approximately in the central part of the Malm carbonate succession in the form of more or less irregular pockets and lenses. They are of small extent, low Al_2O_3 contents, but high in silica and iron. Silica in the bauxites is mainly present in clay minerals. The X-ray analysis showed that the main bauxite mineral is boehmite and rarely gibbsite, which is commonly subordinate. The deposits vary considerably in composition and commonly range from bauxite to silty or sandy bauxitic clays. The bauxites are concordantly overlaid by the Clypeina *limestones, dolomitized limestones and latediagenetic dolomites.*

Key words: bauxite, mineral composition, Malm, Outer Dinarides, Slovenia

I DEPOSITI DI BAUXITE DI ILOVA GORA E ČUŠPERK

SINTESI

I depositi di bauxite di Ilova Gora e Čušperk comprendono i siti di Gradišče, Mali vrh (552 m), Šopeh e Čušperk (SE Slovenia). I blocchi di bauxite sono interstratificati nella parte centrale della successione carbonatica del Giurassico superiore, a formare lenti e tasche più o meno irregolari. Sono di piccola estensione, hanno bassi contenuti di Al_2O_3, ma alti contenuti di Fe_2O_3 e SiO_2. Nella bauxite il silicio è presente principalmente nei minerali argillosi. L'analisi a raggi X ha evidenziato che nella bauxite il minerale essenziale è la boemite e raramente la gibbsite, che comunemente è subordinata. La composizione dei depositi è mutevole, e varia dalla bauxite alle argille bauxitiche. Le bauxiti sono concordantemente ricoperte da calcari di Clypeina*, calcari dolomitizzati e dolomiti tardodiagenetiche.*

Parole chiave: bauxite, composizione minerale, Giurassico superiore, Dinaridi esterne, Slovenia

INTRODUCTION

The Ilova Gora and Čusperk bauxite district is a small area situated about 30 km to the southeast of Ljubljana in the Suha Krajina. The bauxites there are associated with consolidated carbonate rocks of Malm age.

The first discovery of bauxites in the Southern Slovenia was effectuated by Rizzato (Pleničar, 1955), who in 1935 explored several small bauxite deposits of relatively high-iron contents in the Nanos area. Later, Rizzato extended his search for ore bodies into the Hrušica area. In the above-mentioned areas, he dug out several pits and shallow trenches.

Lipold (1858) revealed the general geologic setting of these deposits. Tiringer (1954) gave a review of the up-to-date knowledge of the Slovene bauxite ore deposits. Pleničar (1953, 1955) described several oolitic bauxite and iron-ore deposits of Slovenia.

Intense and systematic detailed explorations of bauxites in Slovenia began actually in the year 1962. Lukacs & Kuhar (1964) presented the annual report on explorations of bauxites in Slovenia in the year 1963. The report involved general data and results of chemical, micropaleontological and X-ray analyses. These authors studied the Šmihel, Budganja vas, Ambrus, Ilova gora and some other Triassic, Jurassic and Cretaceous bauxite occurrences in Slovenia. Buser & Lukacs (1966, 1973) reported on systematic explorations of bauxite in Slovenia, describing eight bauxite stratigraphic horizons. According to them, the Malm bauxite occurs in the form of more or less irregular layer with maximal thickness of 2.5 metres. Šribar (1966) described the Jurassic sediments between Zagradec and Randol in the Suha Krajina area. On the basis of microfossils and the stratigraphic position, she divided the Jurassic succession into the Lower and Middle Liassic, Upper Liassic-Dogger, Lower Malm, and Upper Malm. Gregorič (1969) studied the origin of the red brown soil (terra rossa) lying on the Triassic dolomites in southern Slovenia. She suggested that the red brown soil had developed from insoluble residuum of the dolomites. According to her, the possibility of aeolian formation of the red brown soil in the area of Šmarje Sap near Ljubljana seems to be out of question.

In the Explanatory text for the Basic Geological Map of Slovenia 1:100 000 of the Map Sheet Ribnica, Buser (1974) described the Carnian and Jurassic bauxites. Jurassic bauxites lie upon the Lower Malm oolitic limestones and under the Upper Malm *Clypeina* limestones. The bauxites turned out to originate along the contact between the Lower and Upper Kimmeridgian in the form of a seam thinning laterally. However, the seams and lenses of the Malm bauxites are from several to 250 centimetres thick. Commonly, the bauxites are oolitic by structure, but under and over the oolitic ore there is usually nonoolitic bauxitic sediment. The Malmian bauxites at Laški Potok, St. Anna, on the Mala Gora, at Ambrus, Ilova Gora, Čušperk as well as the largest bauxite outcrops between Šmihel and Budganja Vas are not suitable for production of alumina owing to the too high silica contents (18–28%).

Buser (1979) investigated the geologic structure of the area on the Map Sheet Ribnica, dividing the Jurassic succession in the Lower and Middle Liassic, Upper Liassic and Dogger, the Lower Malm and the Upper Malm.

On the basis of collected micropaleontological data, Dozet (1990, 1996) subdivided the Jurassic and Lower Cretaceous into five cenozones and four subzones.

Strohmenger & Dozet (1991) studied the stratigraphy, facies developments and geochemistry of the Jurassic carbonate rocks in the Suha Krajina. The field and micropaleontological studies showed that at least the uppermost part of Dogger was not deposited there. Dozet (1993) detected the complete Lofer cyclothems in the Lower Liassic beds from the Slovene part of the Outer Dinarides. The main characteristic of the Krka limestones is the well-developed rhythmic sedimentation. Dozet *et al.* (1993) compared the Nanos bauxites with Late Jurassic bauxites from western Istria. They came to the conclusion that paleogeographic and tectonic conditions were rather similar. Dozet (1994a, 1994b) described in detail the Upper Triassic and Jurassic sedimentation in the Suha Krajina area as well as the Malm bauxites at Kočevska reka and Kočevje. Buser & Debeljak (1994/1995) as well as Debeljak & Buser (1997) studied the distribution of lithiotids in the Lower Jurassic beds of south Slovenia. The horizon with bivalves (lithiotid horizon) is attributed to Pliensbachian (Domerian).

Recently, the Jurassic stratigraphy and classification have been described by Strohmenger & Dozet (1991), Dozet (1995), Dozet & Šribar (1997) and Dozet (2000).

The objectives of this paper are, firstly, to describes the bauxite occurrences and geology in the western part of Suha Krajina and, secondly, to present and interpret the data of X-ray analysis.

The article for the first time presents and interprets the data of the Malmian bauxites in the southeastern Slovenia, on the basis of which a correlation of the Malmian bauxites in the whole Outer Dinarides will be made possible.

MATERIAL AND METHODS

Our work is based on the systematic regional geological mapping of the study area for the Geological Map of Slovenia on the scale of 1:50,000, on several detailed field surveys including stratimetric measuring and profiling, and on sedimentological and facies study of the Jurassic rocks in the area under consideration (Fig. 1).

Besides, our work is documented by numerous rock

samples, thin-sections and X-ray diffraction measuring. The bulk mineralogical compositions and clay fraction of samples were determined by X-ray diffraction (XRD) using a Philips diffractometer (PW 3710), goniometer PW 1820, with automatic divergence slit and curved monochromator, operating at 40 KV, 30 mA with CuK_{α} radiation and Ni filter. Scan step was 0.02^{o} with 0.400 s per step.

The stratigraphic relationships have been studied by means of micro- and macrofossils, and by lithologic correlations. The quantitative mineralogical composition of the bauxite samples were determined by X-ray diffraction.

The carbonate rocks are classified according to Folk's (1959) practical petrographic classification of limestones and Dunham's (1962) classification of carbonate rocks according to depositional texture. For the description and classification of the bauxites, the terminology proposed by Bardossy & Nicholas (1974) was used. The colour determinations of bauxite deposits and adjacent carbonate rocks are based on the Munsell Rock Colour Chart.

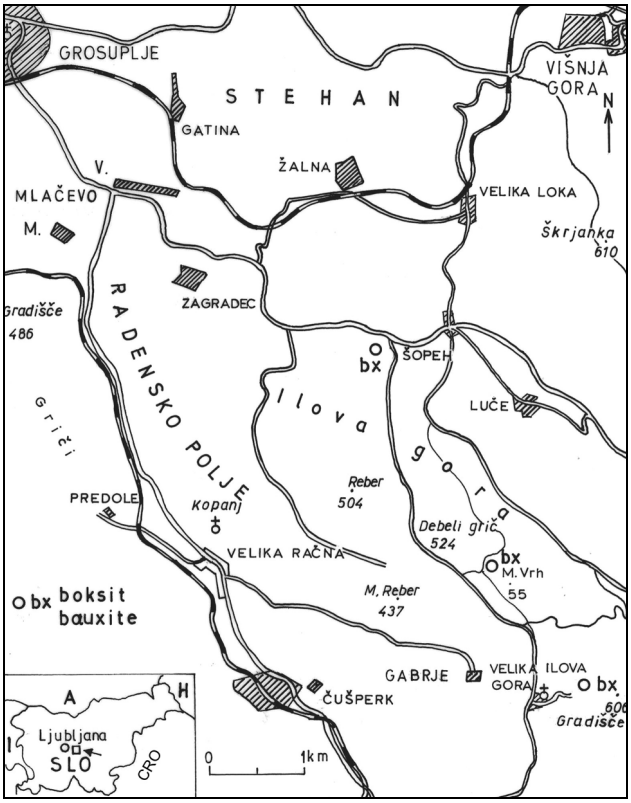

Fig. 1: Location sketch map of the bauxite occurrences in the Western Suha Krajina.
Sl. 1: Zemljepisna karta pojavov boksita v zahodni Suhi Krajini.

RESULTS AND DISCUSSION

General geology

From the geotectonical point of view, the investigated area belongs to the Dinarides, which are divided into the Inner and Outer Dinarides. The Inner Dinarides are built of deeper-water rocks, while the Outer Dinarides are composed of shallow-water sediments. The study area lies in the Outer Dinarides. The previous researchers mostly designated the study area as Dolenjski Kras, but Buser (1974) gave to this tectonic area a more suitable name: Dolenjsko-Notranjska Mesozoic Blocks, or Western Dolenjsko Mesozoic Blocks, to be more precise.

The unit of the Outer Dinarides was originally a relatively large and morphologically poorly differentiated area of predominantly shallow-water carbonate deposits ranging from subtidal to supratidal environments. Carbonate rocks were continuously deposited there from the Upper Triassic to the Lower Tertiary. The platform consisted of a very thick carbonate succession of an average thickness of about 4000 metres. Later, the Outer Dinarides underwent a differentiation due to the formation of the Slovene Basin, and the originally uniform area was dissected into two minor platforms, the Julian and the Dinaric ones (Buser, 1989).

Generally speaking, the syngenetic paleotectonic events have controlled the paleogeographic evolution of the surveyed area and the bauxite accumulation. The neotectonic processes, uplifting the region, brought about the present position of the bauxite outcrops.

Geology of the study area

The study area consists of the Upper Triassic and Jurassic carbonate rocks; limestones, dolomitized limestones, dolomites and carbonate breccias respectively. The listed sediments are shallow marine platform carbonates, formed in a restricted shelf, lagoon and subtidal to supratidal environments. The bauxites and bauxitic clays occur as thin lenses or pods in the topmost part of 450 to 500 metres thick Hočevje Oolitic Group (Dozet, 2000). The lower part of this group, composed of dark oolitic limestones, belongs to the Laze Formation, and the upper one, composed of greyish oolitic limestones, belongs to the Šentrumar Formation (Dozet, 2000).

The regional dip of the Triassic and Jurassic rocks is the southeast.

Bauxite and clay deposits

Bauxites in the Ilova Gora and Čušperk district occur as rather low-grade very small lenses or pockets in the topmost part of the Šentrumar Formation at or near the present land surface. The combination of low grade,

small size, iron-rich and silica-rich makes these deposits of no economic interest. The possibility of discovering new and larger deposits is considered to be unlikely.

Deposits in the district range in size from a few metres to as much as 100 metres and more in greatest areal dimension and from a half to 10 metres in thickness including both bauxite and kaoline. Bauxite occurs commonly in the central part of deposits and grades into kaoline downwards and to all sides. Since some deposits in the Ilova Gora and Čušperk areas are at or very close to the surface, some of the tops have been eroded in several cycles.

Bauxites are pale yellow to tan but may be often in part rusty to dark red and brown. Bauxites are cryptocrystalline, oolitic or pisolitic by texture and rather soft to pretty compact.

Description of the bauxite deposits

The Malm bearing bauxite contact of Ilova Gora lies parallel to the road Grosuplje-Krka towards Ilova Gora. The general direction of the ore-bearing contact is the north-south. In the area with considered outcrops, traces of old excavation have been preserved. The ore-bearing contact is about 15 kilometres long. The bauxite occurrences are found at three localities, namely: Gradišče, Mali Vrh, Šopeh. According to personal communication, the iron ore had still been dug before the year 1900.

The **Gradišče deposit** (Ilova Gora) consists of two smaller erosional nests on the Gradišče hill (552 m) a half kilometre southeast of the Velika Ilova Gora. The reddish brown oolitic bauxite was trapped in poorly developed karst paleorelief, built of light grey to medium light grey, medium-grained oosparitic, intraoosparitic and biolithitic limestones with hydrozoans, sponges, algae and foraminifers. A high percent of Fe_2O_3 (55%) is characteristic for this deposit.

Mali Vrh deposit extends in the west-east direction on the southern slope of the Mali Vrh (552 m) hill along the Lower Malm/Upper Malm contact in the form of several hundred metres long and 45 to 60 metres wide lens. The deposit is composed of four lithological types of bauxites: greyish olive pelitic bauxite, brick-red hematitized pelitic bauxite, yellowish orange cryptocrystalline bauxite and dark reddish brown oolitic bauxite. The thickness of the bauxite horizon is 3 to 5 metres.

Greyish olive bauxites predominate. The bauxites of the Mali Vrh deposit lie between underlying greyish oosparitic limestones with trocholinas, salpingoporellas, hydrozoans, sponges and overlying greyish black stratified *Clypeina* limestones.

The **Čušperk deposit** is represented by 180 metres long and 35 to 50 metres wide lens-like outcrop, lying about 500 metres to the south of Čušperk behind the Žitnik farm. This deposit is five to seven metres thick having an inexpressive paleorelief. The medium-grey, grey and dark grey oosparitic, oncosparitic, ooncosparitic, oointrasparitic and biolithitic limestones with hydrozoans, sponges, bryozoans and microfossils, *Trocholina elongata, Trocholina alpina, Salpingoporella annulata* are covered by the following lithological types of bauxites (from bottom to top): yellowish grey pelitic bauxite, lenses of yellowish orange to dark yellowish orange cryptocrystalline bauxite, lenses of greyish red bauxite, lenses of reddish orange bauxite, olive bauxite with numerous calcitic pseudooolites, greyish red oolitic bauxite, lenses of greyish red pelitic bauxite with bauxitic nodules (nodular bauxite). The greater part of the deposit is filled with the yellowish grey pelitic bauxite. In the upper part of the deposit, greyish red to reddish brown bauxites with pelitic or oolitic texture predominate. The nodular bauxite lies in the central part of the deposits. Fifty centimetres thick yellowish clay constitutes the final layer of the bauxite horizon in the Čušperk deposit. It is covered by the medium grey and medium light grey *Clypeina* biointrasparitic, biointrasparuditic and biomicritic limestone containing beside algae *Clypeina jurassica* the microfossils *Salpingoporella annulata*, Verneulinidae, and gastropods as well. Upwards in the carbonate succession follow medium grey and medium light grey biointrasparudites with the alga *Clypeina jurassica* and tintinninas proving the Upper Malm age of the overlying carbonate sediments.

The **Šopeh deposit** is situated at the Luče-Grosuplje and Ilova Gora-Šopeh cross-roads. It is represented by a roundish outcrop with a diameter about 150 to 200 metres. The footwall of the bauxite is built of the Lower Malm grey to moderate grey, medium-grained massive oosparitic limestone and dolomitized limestone. The deposit is composed of moderate yellowish orange fine-grained bauxite, yellowish grey to white fine oolitic bauxite with rare pisolites, pale red oolitic bauxite with rare pisolites, moderate red oolitic bauxite with rare pisolites, dark red bauxite, breccia-conglomerate consisting of 1 to 3 centimetres poorly-rounded dark red iron-bauxite fragments floating in a greyish orange groundmass and, finally, of pinkish oolitic bauxite composed of pale yellowish brown, orange, moderate reddish orange, light red, grey, greyish red and brick-red ooids.

Mineral composition

The mineral composition of the considered bauxites is not constant. The Al_2O_3 content is the highest in central parts of the considered ore deposits. On the other hand, moving upwards and downwards the ore contains more and more kaoline.

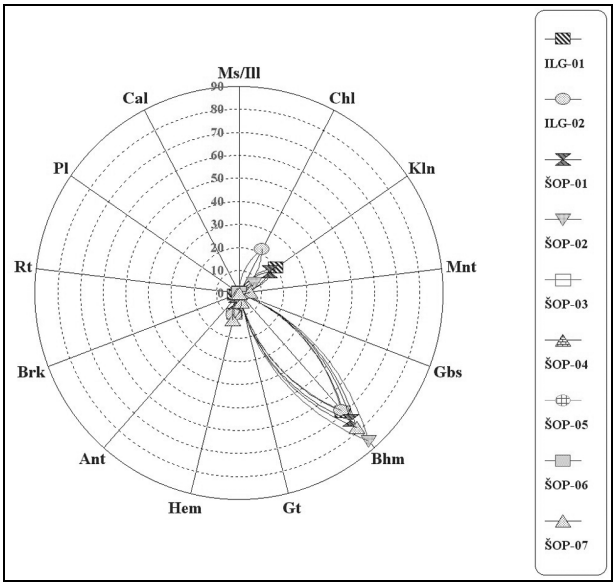

Fig. 2: The mineral composition of the bauxites from Ilova Gora and Šopeh in wt %. Legend: Ms/Ill – muscovite/illite; Chl – chlorite; Kln – kaolinite; Mnt – Ca-montmorillonite; Gbs – gibbsite; Bhm – boehmite; Gt – goethite; Hem – hematite; Ant – anatase; Brk – brookite; Rt – rutile; Pl – plagioclase; Ca – calcite.
Sl. 2: Minaralna sestava boksitov iz Ilove Gore in Šopeha podana v masnih %. Legenda: Ms/Ill – muskovit/illit; Chl – klorit; Kln – kaolinit; Mnt – Ca-montmorillonit; Gbs – gibbsit; Bhm – boehmit; Gt – goethit; Hem – hematit; Ant – anataz; Brk – brookit; Rt – rutil; Pl – plagioklaz; Ca – kalcit.

The mineral composition of the bauxites has been determined by X-ray powder diffraction analysis. In the Ilova Gora and Šopeh deposits, the main quantity of Al_2O_3 is bound to boehmite (Tab. 1, Fig. 2), while the Čušperk deposit, where bauxitic clays occurred, Al_2O_3 is bound to boehmite, muscovite-illite, chlorite and kaolinite (Tab. 2, Fig. 3). However, the Fe_2O_3 is in all occurrences bound to hematite and goethite, while the TiO_2 is associated with anatase, brookite and rutile. Common are goethite, kaolinite, hematite, micas and clay minerals, anatase, brookite and rutile.

Among transparent minerals of the heavy fraction, rare grains of rutile, titanite, zircon, tourmaline, epidote, amphibole, chlorite and muscovite occur. In the light fraction opaque grains prevail. Grains of quartz also occur. On the basis of hitherto established spectrum of heavy minerals it is very difficult to discuss their origin and rocks in their basement.

Tab. 1: The mineral composition of the bauxites from Ilova Gora and Šopeh in wt %. Legend: Ms/Ill – muscovite/illite; Chl – chlorite; Kln – kaolinite; Mnt – Ca-montmorillonite; Gbs – gibbsite; Bhm – boehmite; Gt – goethite; Hem – hematite; Ant – anatase; Brk – brookite; Rt – rutile; Pl – plagioclase; Ca – calcite.
Tab. 1: Mineralna sestava boksita z Ilove Gore in Šopeha v masnih %. Legenda: Ms/Ill – muskovit/illit; Chl – klorit; Kln – kaolinit; Mnt – Ca-montmorillonit; Gbs – gibbsit; Bhm – boehmit; Gt – goethit; Hem – hematit; Ant – anataz; Brk – brookit; Rt – rutil; Pl – plagioklaz; Ca – kalcit.

Locality	Ms/Ill	Chl	Kln	Mnt	Gbs	Bhm	Gt	Hem	Ant	Brk	Rt	Pl	Cal
ILG-01	0	0	20	0	0	69	0	9	0	2	0	0	0
ILG-02	0	22	0	0	0	68	0	10	0	1	0	0	0
ŠOP-01	0	0	16	0	0	74	4	4	2	0	0	0	0
ŠOP-02	0	0	8	0	0	86	4	0	2	0	0	0	0
ŠOP-03	0	0	17	0	0	79	2	0	2	0	0	0	0
ŠOP-04	0	20	0	0	0	69	4	5	2	0	0	0	0
ŠOP-05	0	0	15	7	0	69	0	8	1	0	0	0	0
ŠOP-06	0	0	12	3	2	76	5	0	0	2	0	0	0
ŠOP-07	0	0	0	5	0	78	4	12	0	1	0	0	0

Tab. 2: The mineral composition of the bauxitic clays from the Čušperk occurrences in wt %. (Legend: see Table 1)
Tab. 2: Mineralna sestava boksitne gline iz pojavov pri Čušperku v masnih %. (Legenda: glej Tabelo 1)

Location	Ms/Ill	Chl	Mln	Mnt	Gbs	Bhm	Gt	Hem	Ant	Brk	Rt	Pl	Cal
ČSP-02	29	25	0	0	8	18	6	0	0	0	2	0	12
ČSP-03	55	28	0	0	0	0	9	0	0	0	3	5	0
ČSP-04	21	22	13	0	0	26	3	8	0	0	3	4	0
ČSP-05	0	28	33	0	0	23	5	9	0	0	3	0	0
ČSP-06	0	18	19	0	0	12	2	0	0	0	0	1	48
ČSP-07	0	24	0	0	0	8	0	3	0	0	0	0	64
ČSP-08	31	26	0	0	0	27	0	8	0	0	0	0	7
ČSP-09	0	0	37	0	0	8	0	6	0	0	6	0	43
ČSP-09A	26	16	37	0	0	10	7	0	0	0	4	0	0

Origin of the bauxites

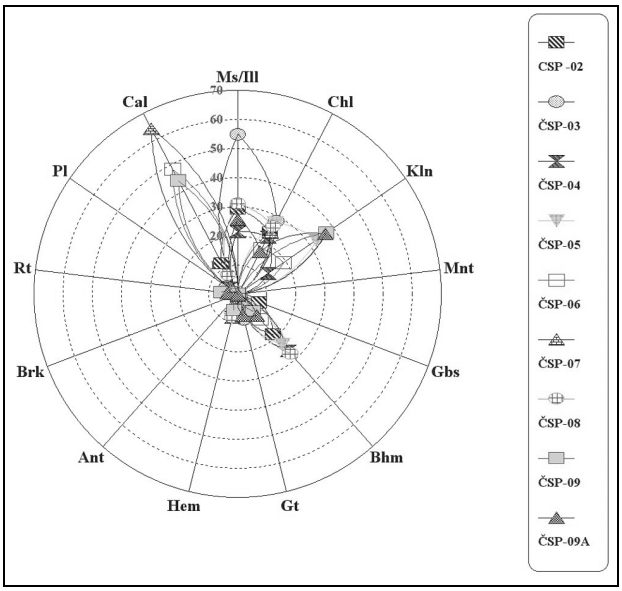

Fig. 3: The mineral composition of the bauxites from Čušperk in wt %. (Legend: see figure 2)
Sl. 3: Mineralna sestava boksitov iz Čušperka podana v masnih %(Legenda: glej sliko 2)

Regarding the way of occurrence and host rock, the Ilova Gora and Čušperk bauxites can be designated as "terra rossa" bauxites or karst bauxites. The main minerals are boehmite, goethite, hematite and kaolinite. The considered bauxites originated at the time of Late Kimmerian phase, which was relatively short. The movements forming a dry land were weak and of epeirogenetic type. This statement is confirmed by almost concordant relationship of the bauxites as well as underlying and overlying carbonate rocks. The Late Kimmerian epeirogenetic movements and weak fault tectonics created poorly developed, inexpressive paleorelief. On the carbonate surface weathering, karstification and denudation took place. Subsequently, the karstification was interrupted by bauxitization and accumulation of bauxite material of the "terra rossa" type into small depressions. According to Maksimović & Buser (1986), along two vertical profiles in the Logatec locality a strong enrichment of the mobile trace elements is exhibited (Be, Ni, Co, Cu, Zn, Y, La, Pb) towards the basement limestone, indicating that the bauxitization process took place *in situ* of the present position of the bauxites.

However, on the basis of all available data we can conclude that the source material originated from the insoluble residue of carbonate footwall rocks and allochthonous eolian material.

CONCLUSIONS

The Suha Krajina bauxite occurrences and deposits occur approximately in the middle part of the Malm stratigraphic sequence. Since the bauxites and bauxitic clays can be found only in the top of the Lower Kimmeridgian limestones, they are considered to be of the Middle Kimmeridgian age.

The bauxites in question lie between the underlying greyish oosparitic limestones with trocholinas, salpingoporellas, hydrozoans, sponges and the overlying dark *Clypeina* and *Tintinnina* carbonate rocks.

Our investigations of the Ilova Gora and Čušperk bauxite district confirm the early prospecting of Lukacs & Kuhar (1964) as well as Buser (1974). In general, the deposits are low-grade bauxites; they are small and the area of their occurrence is small. Bauxite and bauxitic clays occur in lenses and pockets. Our prospecting indicates that the individual deposits are small and erratic in distribution and mostly high in iron oxides and silica. Lateral gradations in composition of the bauxite ore within occurrences and deposits are common. Most of the material in the deposits is classified as grade C_1 bauxite.

ACKNOWLEDGEMENT

The authors wish to express their cordial thanks to the Ministry of High Education, Science and Technology of the Republic of Slovenia and to the Geological Survey of Slovenia for their financial support in the detailed and systematic regional research carried out in the western part of Suha Krajina.

LEŽIŠČA BOKSITOV NA OBMOČJU ILOVE GORE IN ČUŠPERKA

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POVZETEK

Opisujemo pojave in ležišča boksitov na območju Ilove gore in Čušperka, ki so nanizani v obliki leč, žepov in gnezd vzdolž rudonosnega kontakta spodnji kimmeridgij/zgornji kimmeridgij. Rudonosno območje Ilova gora-Čušperk obsega sledeče pojave oziroma ležišča boksitne rude: Gradišče, Mali vrh (552 m), Žitnik (Čušperk) in Šopeh, ki leže okoli 5 km jugovzhodno od Grosuplja.

Malmski rudonosni kontakt na območju Ilove gore leži vzporedno s cesto od odcepa ceste Grosuplje-Krka na Ilovo goro. Generalna smer kontakta je sever-jug. Na izdankih boksita Ilove gore so marsikje ohranjeni sledovi starega odkopavanja. Rudonosni kontakt je dolg 15 km. Boksitni pojavi so odkriti na treh lokacijah: Gradišče, Mali vrh (552 m) in Šopeh. Po ustnem izročilu so na območju Gradišča kopali železovo rudo vse do leta 1900. Kemična analiza vzorca rude iz tega območja je res pokazala visok odstotek železa (54,59%). Nekateri vzorci rude Ilove gore imajo za izkoriščanje razmeroma ugoden odstotek SiO_2. Rudno telo na lokaciji Žitnik na območju Čušperka ima obliko 180 m dolge in 35 m široke leče, ki je konkordantna s plastmi talnine in krovnine. V talnini močno prevladujejo sivkasti oosparitini, onkosparitni in oonkosparitni apnenci s foraminiferami, algami, hidrozoji in spongijami. Najpomembnejši fosili so Cladocoropsis mirabilis, Trocholina elongata, Trocholina alpina *in* Salpingoporella annulata*. V krovnini so temnosivi do sivkastočrni plastnati apnenci, dolomitizirani apnenci in dolomiti z algami, gastropodi, foraminiferami in tintininami. Za biostratigrafijo so poleg tintinin najpomembnejše alge* Clypeina jurassica*, ki so bile pri nas razširjene v zgornjem malmu.*

V nahajališčih Ilova gora in Šopeh je glavna količina Al_2O_3 vezana na boehmite, v nahajališču Čušperk, kjer nastopajo boksitne gline, pa je količina Al_2O_3 vezana na boehmit, muskovit-illit, klorit in kaolinit. Fe_2O_3 je v vseh nahajališčih vezan na hematit in goethit, TiO_2 pa je vezan na anataz, brookit in rutil.

Obravnavani boksiti pripadajo "terra rossa" tipu boksitov oziroma kraškim boksitom. Boksiti raziskanega ozemlja so nastali v času poznokimmerijske faze, ki je bila razmeroma kratka. Premikanja, ki so povzročila nastanek kopna, so bila šibka in epirogenetskega tipa. To potrjujeta neizraziti paleorelief in konkordantna lega rudnih teles ter plasti talnine in krovnine. Na površini spodnjemalmske karbonatne skladovnice je potekalo preperevanje, izluževanje, raztapljanje, zakrasevanje in denudacija.

Boksitni material se je nakopičil v številnih majhnih depresijah, potem je nastopila boksitizacija, ki je zaustavila zakrasevanje karbonatnih tal. Transport netopnega ostanka karbonatnih kamnin se je dogajal s spiranjem, s površinskimi in podzemeljskimi vodnimi tokovi ter s pomočjo vetra. Sestava boksitov se znatno spreminja zlasti v vertikalni smeri, tako da boksit prehaja v glinasti boksit in boksitno glino.

Boksitna ležišča Ilove gore in Čušperka imajo majhen gospodarski pomen, saj imajo majhen obseg, nizko vrednost Al_2O_3 ter razmeroma visoko vsebnost Fe_2O_3 in SiO_2. Večina boksitne rude na območju Ilove gore in Čušperka je klasificirana kot C_1 zaloge.

Ključne besede: boksit, mineralna sestava, malm, Zunanji Dinaridi, Slovenija

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NUMULITINE IZ NAHAJALIŠČA PAPRATA NA KRKU

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IZVLEČEK

Pri Paprati na vzhodnem delu otoka Krk sta v klastitih nahajališči numulitin. Eno od njiju je zgornjecuisijske starosti, drugo iz spodnjega lutetija. Vendar po starosti med njima ni velike razlike.

Ključne besede: numulitine, eocen, otok Krk, Hrvaška

NUMMULITI DEL SITO PAPRATA SULL'ISOLA DI VEGLIA

SINTESI

Nei pressi di Paprata, nella parte orientale dell'isola di Veglia, ci sono due strati di ritrovo di nummuliti. Il primo sito risale al Cuisiano superiore, mentre il secondo al Luteziano inferiore. Non ci sono tra loro grosse differenze d'età.

Parole chiave: nummuliti, eocene, isola di Veglia, Croazia

UVOD

Nahajališče Paprata je bilo v zadnjem času omenjeno dvakrat (Klepač & Pavlovec, 2001; Pavlovec & Klepač, 2003). Papratska favna je danes nekoliko dopolnjena z nekaterimi vrstami in drugimi podatki.

V spodnjem horizontu pri Paprati so bile ugotovljene naslednje numulitine *Assilina maior maior* Heim, *Assilina maior punctulata* Schaub, *Assilina cuvillieri* Schaub, *Assilina suteri* Schaub, *Nummulites campesinus* Schaub in *Nummulites boussaci* Rozlozsnik (morda prehod med *N. praelorioli* in *N. boussaci*?). Iz zgornjega horizonta so *Assilina spira abrardi* Schaub, *A. suteri*, *Nummulites obesus* D'Archiac, *Nummulites lehneri* Schaub, *Nummulites verneuili* D'Archiac & Haime, *Nummulites praelorioli* Herb & Schaub in *Nummulites perplexus* Schaub.

Pavlovec in Klepač (2003) ugotavljata, da v večini nahajališč numulitin na Krku niso ohranjene prave biocenoze. V apnencih so v smislu klasifikacije numulitinskih nahajališč (tip 1a, Pavlovec, 2003) primarna nahajališča z nekoliko spremenjeno prvotno biocenozo. To pomeni, da je favna vsaj nekoliko premetana, čeprav lahko le na manjše razdalje. V flišu in drugih klastitih so numulitine vedno na sekundarnem mestu (tip 3a, Pavlovec, 2003), saj so bile prenesene iz karbonatne platforme. Za takšno razlago so bili narejeni modeli (Pavlovec, 1969, 1988). Iz vsega tega sledi, da numulitine v apnencih na Krku ne kažejo prave prvotne biocenoze, še manj v klastitih. Vendar so največkrat sinhrone s plastmi celo v flišu oziroma v klastitih, kjer nismo ugotovili mešanih, različno starih oblik.

NAHAJALIŠČE

V tej razpravi obravnavani nahajališči numulitin ležita zahodno od majhne vasice Paprata (zahodno od kraja Risika) med Dobrinjem in Vrbnikom na otoku Krku. Pot se spušča od Paprate proti zahodu v dolino potoka, ki teče proti jugu in blizu Vrbnika ponikne. Takoj vzhodno nad potokom so laporovci, v katerih so poleg numulitin korale in mehkužci. To nahajališče označujemo kot spodnji horizont pri Paprati. Pot se na desnem bregu dviga in blizu najvišjega dela je v peščeno laporni plasteh drugo nahajališče numulitin. Označujemo ga zgornji horizont pri Paprati.

Nahajališči pri Paprati nam je pokazala geologinja Koraljka Klepač iz Prirodoslovnega muzeja na Reki. Opisani primerki so shranjeni večinoma v Prirodoslovnem muzeju na Reki, nekaj tudi v zbirki Katedre za geologijo in paleontologijo Univerze v Ljubljani.

OPISI NUMULITIN

Assilina maior maior Heim, 1908

1976. *Assilina major* Heim, 1908 – Rahaghi & Schaub, 779, tab. 7, sl. 8-10

1981. *Assilina maior* Heim, 1908 – Schaub, 200-202, tab. 16 h, tab. 75, sl. 1-26, tab. 76, sl. 1-37, tab. 77, sl. 1-18

2003. *Assilina maior* Heim, 1908 – Pavlovec & Klepač, 222-223

Mikrosferična generacija

Precej tanka, ploščata hišica je na sredini rahlo odebeljena. Večkrat je nekoliko nagubana. Velikosti hišic s Krka so med 14 in 26 mm, debeline med 2 in 3 mm. Po Schaubu (1981) so velikosti hišic med 17 in 26 mm. Pri polmeru 10,5 mm ima 10 zavojev. Precej je podobna povprečno večji podvrsti *Assilina spira abrardi*, katere velikosti so po Schaubu (1981) med 18 in 32 mm. Ima tudi višje zavoje kot *A. maior maior*, pri kateri so kamrice bolj visoke kot dolge. Septa so spodaj skoraj pravokotna na zavoj, zgoraj se rahlo usločijo nazaj.

Megalosferična generacija

Velikosti največjih hišic iz Paprate so blizu 10 mm, po Schaubu (1981) med 6 in 10 mm. Hišica je bolj ali manj enakomerno debela in ima na površini vidno notranjo zgradbo, to so sledovi sept in zavojnega roba. Granule so najgostejše v srednjem delu hišice.

A. maior maior je živela v zgornjem cuisiju in na bazi lutetija. V nekaterih plasteh Slovenije, Istre, Kvarnerskih otokov in v Dalmaciji je zelo pogosta (Cimerman *et al.*, 1974; Pavlovec & Simčič, 1999). V profilu Skradin – Dubravice je v apnenčevem horizontu izredno pogosta kot monospecifična oblika (Drobne *et al.*, 1991). Na Krku je bila že ugotovljena v spodnjem horizontu pri Paprati in pri Murvenici (Pavlovec & Klepač, 2003) ter pri Dobrinju (Schaub, 1981).

Assilina maior punctulata Schaub, 1981

1981. *Assilina maior punctulata* nov. ssp. – Schaub, 205, tab. 17 c, tab. 97, sl. 13-21

1999. *Assilina maior punctulata* Schaub – Pavlovec & Simčič, 271

2004. *Assilina maior punctulata* Schaub – Pavlovec, 32, tab. 1, sl. 3

Mikrosferična generacija

Ploščata hišica je pri nekaterih primerkih nekoliko valovita. Na površini so zlasti v srednjem delu močne granule, ki so v zunanjem delu nežnejše in so tudi med sledovi sept. Velikosti hišic so med 15,3 in 15,5, mm, debeline med 2,5 in 2,7 mm. Po Schaubu (1981) so velikosti od 16 do 20 mm, omenja pa primerke iz Dobrinja

na Krku, velike med 21 in 23 mm, debeline od 2 do 2,8 mm. To pomeni, da velikosti precej variirajo. Zavoji, zavojni rob in septa so podobni podvrsti *A. maior maior.*

Oblika *A. maior punctulata* je zelo podobna podvrsti *A. maior maior.* Zanimivo je, da obeh podvrst Schaub (1981) v svoji monografiji ne opisuje v istem filogenetskem nizu. Pravi, da "l'appartenance au phylum d' *A. spira* est incontestable". *A. maior punctulata* je bila prvič opisana iz nahajališča Noax v Furlaniji. Ugotovljena je bila tudi v Goriških brdih (Pavlovec & Simčič, 1999; Pavlovec, 2004). S Krka je znana iz Dobrinja (Schaub, 1981) in zdaj še iz spodnjega horizonta pri Paprati. Ta podvrsta je zgornjecuisijska.

Assilina spira abrardi Schaub, 1981

1969. *Assilina spira* (De Roissy) – Pavlovec, 168–169, 194 (partim), tab. 5, sl. 1-2, tab. 6, sl. 1–3

1977. *Assilina spira* 1 (n.sp.?) sensu Pavlovec 1969 – Drobne *et al.*, 47, tab. 9, sl. 3

1981. *Assilina istrana* n.sp. – Pavlovec, 67–69, tab. 1, sl. 1–7

1981. *Assilina spira abrardi* nov. ssp. – Schaub, 202–203, sl. 114, tab. 16 i, tab. 78, sl. 6, 11–20, tab. 79, sl. 1–16, tab. 80, sl. 1–13

1987. *Assilina* aff. *spira abrardi* Schaub – Pavlovec, 67, tab. 2, sl. 5

2003. *Assilina spira abrardi* Schaub, 1981 – Pavlovec & Klepač, 230–231

Mikrosferična generacija

Rahlo valovita hišica je tanka, v sredini večkrat malo odebeljena. Nad septami in deloma med njimi so na površini okrogle granule, ki se najbolj zgostijo v centralnem delu hišice. Premeri hišic so med 18 in 20 mm, debeline okrog 2 mm. Manjše hišice s premeri pod 15 mm (12–15) so verjetno juvenilni primerki. Schaub (1981) navaja premere med 18 in 32 mm ter debeline med 1,8 in 2,3 mm. Na površini se jasno vidi notranja zgradba, to so zavojni rob in septa. Zavoji se enakomerno višajo, zavojni rob je močan. Septa so malo usločena in v zgornjem delu upognjena nekoliko nazaj, v spodnjem delu so skoraj ravna in pravokotna na zavojni rob. Višina kamric prekaša njihovo dolžino.

Megalosferična generacija

Diskasta hišica se od roba do sredine le malo odebeli. Premeri hišic so od 7,6 do 9 mm in debeline okrog 1,8 mm. Po Schaubu (1981) so premeri med 7 in 10,5 mm, debeline pa med 1 in 1,5 mm. Na površini je jasno viden potek zavojnega roba in sept. Zlasti v centralnem delu je veliko okroglih granul, deloma po sledeh sept, deloma po zavojnem robu. Proti zunanjemu robu hišice je granul manj, tako da se jasneje kažejo septalni podaljški. Zavoji se enakomerno in počasi višajo. Zavojni rob je močan. Septa so rahlo upognjena.

Podvrsta *A. spira abrardi* je v Istri in na Kvarnerskih otokih zelo pogosta (Schaub, 1981; Pavlovec, 1988 = *Assilina istrana*; Pavlovec, 1993), tako da so Francozi (Aubouin & Neumann, 1960) dali ime asilinski apnenec. Tudi v zgornjem horizontu v Paprati je ta podvrsta pogosta. Na Krku je bila najdena še zahodno od Vrbnika (Malaroda & Pavlovec, 2000), v nahajališčih Suha Ričina, Voz in Dobrinj (Pavlovec & Klepač, 2003). Živela je v spodnjem lutetiju. Nekateri primerki so po malo daljših kamricah nekoliko podobni spodnjelutetijski obliki, ki jo Schaub (1981) označuje kot *A.* aff. *maior* in je na prehodu med *A. maior maior* in *A. spira abrardi.* Morda to kaže na nekoliko starejši del spodnjega lutecija.

Assilina cuvillieri Schaub, 1981
(Tabla 1, Sl. 1)

1981. *Assilina cuvillieri* nov. sp.– Schaub, 210–211, tab. 18 g, tab. 88, sl. 22–26, tab. 89, sl. 1–49

1985. *Assilina cuvillieri* Schaub – Pavlovec, 226, tab. 9, sl. 1

1999. *Assilina cuvillieri* Schaub – Pavlovec & Simčič, 271–272, tab. 1, sl. 5

2003. *Assilina cuvillieri* Schaub, 1981 – Pavlovec, 235, tab. 1, sl. 3–4

2003. *Assilina cuvillieri* Schaub, 1981 – Pavlovec & Klepač, 220–221

Mikrosferična generacija

Ploščata hišica je v sredini nekoliko dvignjena in prav na sredi ima majhno vdrtino. Najgostejše granule so v sredini in sledijo notranji zgradbi, to je septam in zavojnemu robu. V zunanji polovici granul ni, pač pa so dobro vidni sledovi sept in zavojnega roba. Velikosti hišic so najpogosteje med 13 in 14 mm, debeline med 2,2 in 2,3 mm. Po Schaubu (1981) so velikosti med 10 in 17 mm, debeline med 1,5 in 2,5 mm (v besedilu je napačno navedeno za debeline med 0,15 in 0,25 mm, saj so že debeline hišic megalosferične generacije med 1 in 2 mm). Zavoji se enakomerno in počasi dvigajo. Kamrice so včasih izometrične, včasih so nekoliko bolj visoke kot dolge. Elementi notranje zgradbe, to so septa in zavojni rob, so tanki. Septa so samo zgoraj upognjena nekoliko nazaj.

Megalosferična generacija

Površinsko strukturo ima enako kot mikrosferična generacija. Velikosti hišic so okrog 5 mm in debeline okrog 1,3 mm. Po Schaubu (1981) so velikosti med 4 in 7,5 mm, debeline med 1 in 2 mm.

V spodnjem horizontu pri Paprati je vrsta *Assilina cuvillieri* zelo pogosta. Našli so jo tudi pri Omišlju (Pavlovec & Klepač, 2003) in pri Dobrinju na Krku (Schaub, 1981), v Goriških brdih, pri Ilirski Bistrici in Izoli (Cimerman *et al.*, 1974; Pavlovec, 1985, 2003). Ta vrsta je živela v zgornjem cuisiju.

Assilina suteri Schaub, 1981

1974. *Assilina medanica* n.sp., oblika A – Pavlovec in Cimerman *et al.*, tab. 15, sl. 3–6

1981. *Assilina suteri* nov. sp. – Schaub, 216–217, tab. 17 f, tab. 95, sl. 34–53, tab. 69, sl. 1–9

1999. *Assilina suteri* Schaub – Pavlovec & Simčič, 272, tab. 1, sl. 1 in 7

2003. *Assilina suteri* Schaub, 1981 – Pavlovec, 235, tab. 1, sl. 5

Mikrosferična generacija

Najden je bil primerek (velikosti 6,1 mm), ki pa ni v celoti ohranjen. Schaub (1981) navaja velikosti 8 do 15 mm. Na površini hišice so v srednjem delu močni radialni grebeni. Ob zunanjem robu sledijo grebeni, septam in zavojnemu robu. Prvi zavoji se zelo nizki, zunanji se hitreje višajo. Septa so skoraj ravna ali le malo usločena.

Megalosferična generacija

Lečasta hišica se proti sredini počasi debeli. V centralnem delu površine so močne goste granule, ki sledijo septalnim podaljškom in so tudi na njih. V vmesnih prostorih ni granulacije. V bližini roba hišice je na površini viden potek zavojnega roba. Premer hišice enega najdenega primerka je 5,1 mm in njena debelina 1,5 mm, velikost drugega je 3,1 mm. Po Schaubu (1981) so hišice velike med 3,5 in 6,5 mm ter debele med 1,5 in 2,2 mm.

Vrsta *A. suteri* se pojavlja v spodnjem in zgornjem horizontu pri Paprati, vendar je povsod zelo redka. Na Krku je bila že ugotovljena (Schaub, 1981) pri Dobrinju (vrh zgornjega cuisija) in pri Vrbniku (baza lutetija in spodnji lutetij). V drugih nahajališčih je znana iz spodnjega lutetija, ponekod iz njegovega bazalnega dela.

Nummulites campesinus Schaub, 1966

1966. *Nummulites campesinus* nov. sp. – Schaub, 361–367, sl. 3 a,b, tab. 1, sl. 1–4

1973. *Nummulites campesinus* Schaub – Kapellos, 77–81, sl. 162–171, tab. 47, sl. 1–9, tab. 48, sl. 1–4

1974. *Nummulites campesinus* Schaub – Cimerman *et al.*, 66, tab. 17 in 18

1981. *Nummulites campesinus* Schaub, 1966 – Schaub, 83–85, sl. 72, 74, 81, tab. 2 g, h, tab. 7, sl. 23–44, tab. 8, sl. 1–22, tab. 9, sl. 1–20

1999. *Nummulites campesinus* Schaub – Pavlovec & Simčič, 273, tab. 2, sl. 7

Mikrosferična generacija

Lečasta hišica je velika 9,5 mm in debela 5 mm, po Schaubu (1981) so velikosti med 5 in 12 mm, debeline med 6 in 8,5 mm. Zavoji se precej hitro višajo, zavojni rob je močan. Septa so v zunanji polovici močno nagnjena in usločena, včasih celo potegnjena nazaj. Kamrice imajo zlasti v zunanjih zavojih večjo dolžino kot višino, nekatere so zelo dolge.

Vrsta *N. campesinus* je živela v zgornjem cuisiju. V Sloveniji je kar pogosta pri Vipolžah v Goriških brdih (Cimerman *et al.*, 1974). Na Krku je bila najdena pri Dobrinju (Schaub, 1981). Spodnji horizont pri Paprati je zdaj drugo nahajališče na tem otoku, vendar je tam redka.

Nummulites obesus D'Archiac, 1852

1981. *Nummulites obesus* D'Archiac, 1852 – Schaub, 85–86, tab. 2 i, tab. 10. sl. 1–55

1991. *Nummulites obesus* D'Archiac & Haime, 1853 – Kleiber,53, tab. 1, sl. 20, tab. 4, sl. 3

Mikrosferična generacija

Hišica je debela, lečasta. Premeri so med 7,7 in 9,8 mm, debeline med 5,5 in 6 mm, po Schaubu (1981) 8 do 13 mm in 4 do 5,5mm. Pri nekaterih primerkih so skoraj po celotni površini hišice goste, majhne, okrogle granule, pri drugih jih je največ v srednjem delu hišice, medtem ko se proti robu jasneje vidijo radialni septalni podaljški. Tudi med septalnimi podaljški so ne posebno goste granule.

Schaub (1981) in Kleiber (1991) pravita, da je najteže med podobnimi oblikami ločiti vrsti *N. obesus* in *N. lehneri* Schaub. Vendar im prvi nekoliko močnejše granule in proti zunanjemu robu hišice bolj izrazite septalne podaljške.

N. obesus je spodnjelutetijska vrsta. Ugotovljena je bila že v apnencih Istre (Pavlovec & Majcen, 1986). V zgornjem horizontu pri Paprati je precej pogosta.

Nummulites lehneri Schaub 1962

1962. *Nummulites lehneri* nov. sp. – Schaub, 530–535, sl. 1–3, tab. 1, sl. 1–10

1981. *Nummulites lehneri* Schaub, 1962, – Schaub, 97–98–10, tab. 4 b, tab. 10, sl. 61–73, tab. 11, sl. 1–12

1991. *Nummulites lehneri* Schaub, 1962 – Kleiber, 71, sl. 17 i,k, tab. 1, sl. 22, tab. 4, sl. 5

2003. *Nummulites lehneri* Schaub, 1962 – Pavlovec & Klepač, 210–211

Mikrosferična generacija

Lečaste hišice iz Paprate so velike med 7 in 8 mm, drugod na Krku (Suha Ričina, Murvenica; Pavlovec & Klepač, 2003) so tudi večje, med 10 in 15 mm. Schaub (1962, 1981) navaja velikosti med 10 in 14,5 mm. Med zavitimi septalnimi podaljški so na površini številne granule. Zavojev je do 20. Notranji so višji, zunanji se znižajo. Septa so nagnjena in ukrivljena. V notranjih zavojih so kamrice izometrične ali včasih celo z večjo višino kot dolžino. V zunanjih zavojih se močno podaljšajo, tako da dolžina presega višino.

Zanimiv je primerek iz spodnjega horizonta pri Paprati. Velikost hišice s približno 15 zavoji je 9,2 mm, de-

belina 5 mm. Zelo je podoben vrsti *N. lehneri* in morda še bolj zgornjecuisijski obliki, ki jo Schaub (1981) označuje kot *N.* aff. *lehneri*. Vendar se je med temi podobnimi numuliti (*N. lehneri, N. gallensis* Heim, *N. obesus* in še nekaterimi) zelo težko odločiti za natančno determinacijo. Tudi Schaubovi primerki *N.* aff. *lehneri* kažejo precejšnje variiranje, tako da je nekatere skoraj nemogoče ločiti od tipičnih predstavnikov vrste. Omenjeni numulit iz Paprate vsekakor kaže na bližino podobnih lutetijskih vrst oziroma na visoko lego spodnjega horizonta pri Paprati v zgornjem cuisiju. Omeniti moramo še primerke *N.* aff. *lehneri* sensu Schaub 1981 (Pavlovec & Simčič, 1999) iz Vipolž v Goriških brdih. Ti se nekoliko ločijo od omenjenega primerka iz Paprate.

Vrsta *N. lehneri* v zgornjem horizontu pri Paprati ni pogosta. Na Krku so jo že našli pri Vodicah (Schaub, 1981), Suhi Ričini in Murvenici (Pavlovec & Klepač, 2003). Znana je tudi iz fliša jugozahodne Slovenije, Istre in Kvarnerja (Pavlovec, 1976, 1982). Živela je v spodnjem lutetiju.

Nummulites verneuili D'Archiac & Haime, 1853
(Tabla 1, Sl. 2, 3)

1962. *Nummulites verneuili* D'Archiac & Haime – Schaub, 539, sl. 5a, 6

1976. *Nummulites verneuili* D'Archiac & Haime – Rahaghi & Schaub,774, tab. 3, sl. 13–14

1981. *Nummulites verneuili* D'Archiac & Haime, 1853 – Schaub, 103–104, sl. 75, 84–85, tab. 4 k, tab. 2, sl. 1–19

1984. *Nummulites verneuili* D'Archiac & Haime, 1853 – Serra–Kiel, 73–74, tab. 3, sl. 13–17, tab. 4, sl. 1–3

1991. *Nummulites verneuili* D'Archiac & Haime – Kleiber, 73, sl. 17 l,m, tab. 1, sl. 23, tab. 3, sl. 25

2003. *Nummulites verneuili* d'Archiac & Haime, 1853 – Pavlovec & Klepač, 218–219

Mikrosferična generacija

Na površini so goste, tanke in malo zavite septalne linije in goste granule, ki jih je največ v srednjem delu hišice. Velikosti debelih ležastih hišic so okrog 10 mm, njihove debeline med 4 in 6 mm (nekaj tipičnih primerkov: 8,7/4 mm, 9,6/6 mm, 9,8/4,5 mm, 9,8/4,6 mm, 10/4,3 mm). Zavoji so gosti in se precej enakomerno dvigajo. Zavojni rob je v zunanji polovici močan. Septa so nagnjena in malo ukrivljena, dolžina kamric pa prekaša njihovo višino.

Megalosferična generacija

Hišica je majhna, po Schaubu (1981) med 3 in 4 mm. Na površini ima močne, okrogle granule in radialne grebene. Zavojni rob je močan, septa so nagnjena in malo usločena. Začetna kamrica je velika in okrogla.

N. verneuili je živel v spodnjem lutetiju. Pri nas ta vrsta ni posebno pogosta, Schaub (1981) jo je ugotovil v spodnjelutetijskih plasteh pri Vodicah na Krku, zdaj je bila najdena v zgornjem horizontu pri Paprati in pri Dobrinju (Pavlovec & Klepač, 2003).

Nummulites sp. (aff. *verneuili)*
(Tabla 1, Sl. 4)

Nekateri primerki iz zgornjega horizonta v Paprati so podobni vrsti *Nummulites friulanus* Schaub predvsem po površinski granulaciji megalosferične generacije, ki je posuta z močnimi, okroglimi granulami. Vendar ima pravi *N. friulanus* višje zavoje. Velikosti mikrosferične generacije iz Paprate so manjše, kot jih navaja Schaub (1981), to je med 12 in 20 mm, medtem ko so pri naših primerkih pod 12 mm.

Kljub navedenim razlikam se ne moremo odločiti za opis morebitne nove vrste, ker so numuliti iz Paprate vsekakor blizu obliki *N. verneuili*. Možno je, da so naši numuliti nekoliko starejši primerki te vrste, se pravi, da so iz starejšega lutetija. To je povsem mogoče, saj je zgornji horizont v Paprati spodnjelutetijski. Vsekakor pa ne sodijo med oblike, ki jih navaja Schaub (1981) kot *N.* aff. *verneuili* iz srednjega lutetija, kajti ti so večji od tipičnih predstavnikov vrste in imajo izrazito znižane zunanje zavoje.

Nummulites praelorioli Herb & Schaub, 1963
(Tabla 1, Sl. 4)

1963. *Nummulites praelorioli* nov. sp. – Herb & Schaub, 979, sl. 3, 5, tab. 1, sl. 1–4

1969. *Nummulites praelorioli* Schaub – Pavlovec, 11 in 39, tab. 2–3

1973. *Nummulites praelorioli* Herb & Schaub – Kapellos, 90, sl. 218–222, tab. 46, sl. 9

1999. *Nummulites praelorioli* Herb & Schaub – Pavlovec & Simčič, 275

2003. *Nummulites praelorioli* Herb & Schaub, 1963 – Pavlovec & Klepač, 216–217

Mikrosferična generacija

Tanka hišica se proti sredini počasi nekoliko odebeli. Na površini so goste meandrirajoče septalne linije in nežne, ne posebno goste granule. Premer hišice je 17 mm, debelina 5 mm, po Schaubu (1981) so velikosti hišic med 14 in 18 mm, debeline med 2,5 in 3,6 mm. Zavojni rob je močan, najdebelejši je v srednjem delu hišice. Zavoji se dokaj enakomerno dvigajo in potekajo nekoliko nepravilno. Septa so v notranjih zavojih gosta in močno ukrivljena, v zunanjih pa so vse bolj ležeča in potegnjena nazaj. V zunanjih zavojih so kamrice podaljšane.

Ta vrsta je bila že ugotovljena v Istri, v Goriških brdih, na Krku pa v zgornjecuisijskih plasteh pri Paprati, Vozu, Murvenici (Pavlovec & Klepač, 2003) in Dobrinju (Schaub, 1981). Živela je v zgornjem cuisiju in spod-

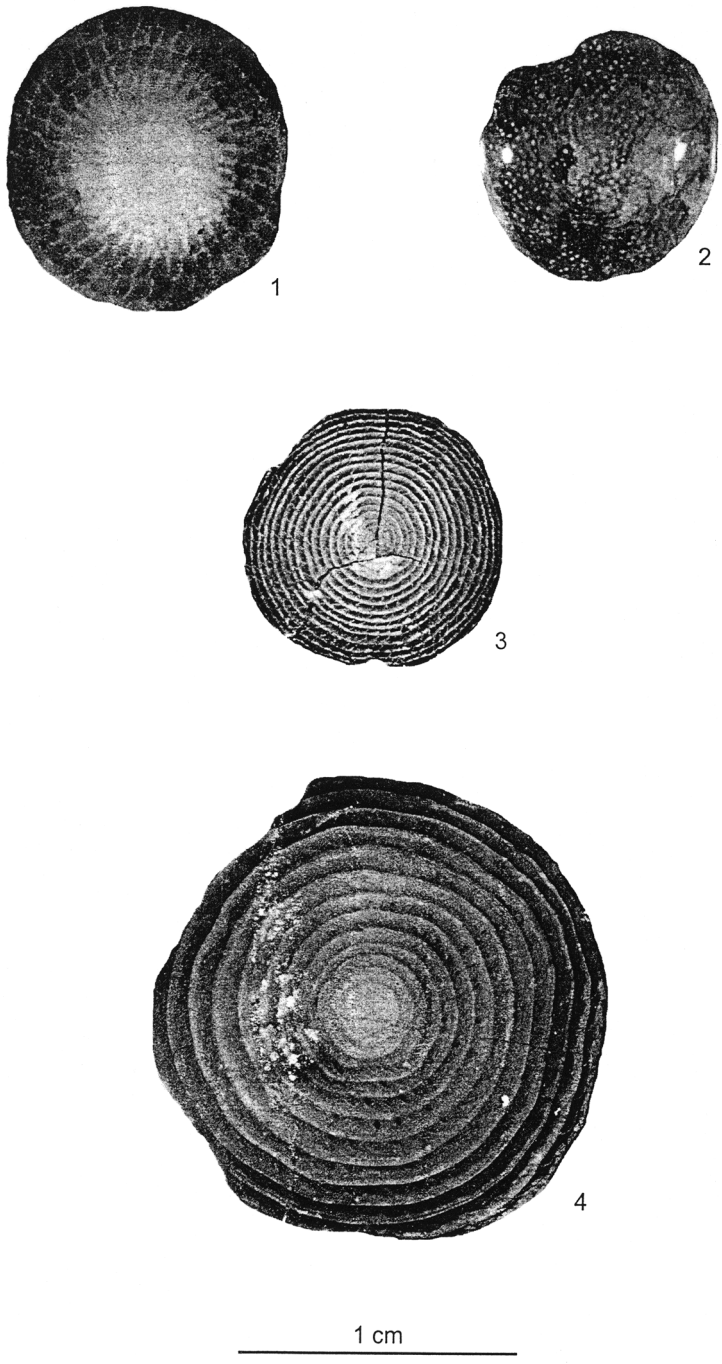

Tabla 1 / *Plate 1:*

Sl. 1: *Assilina cuvillieri* ***Schaub, oblika B, površina hišice. Paprata, spodnji horizont.***
Fig. 1: *Assilina cuvillieri* ***Schaub, B form, surface of the test. Paprata, lower horizon.***
Sl. 2: *Nummulites verneuili* ***D'Archiac & Haime, oblika B, površina hišice. Paprata, zgornji horizont.***
Fig. 2: *Nummulites verneuili* ***D'Archiac & Haime, B form, surface of the test. Paprata, upper horizon.***
Sl. 3: *Nummulites verneuili* ***D'Archiac & Haime, oblika B, ekvatorialni prerez. Paprata, zgornji horizont.***
Fig. 3: *Nummulites verneuili* ***D'Archiac & Haime, B form, equatorial section. Paprata, upper horizon.***
Sl. 4: *Nummulites praelorioli* ***Herb & Schaub, oblika B, ekvatorialni prerez. Paprata, zgornji horizont.***
Fig. 4: *Nummulites praelorioli* ***Herb & Schaub, B. form, equatorial section. Paprata, upper horizon.***

njem lutetiju. V zgornjem horizontu pri Paprati je bil ugotovljen en sam dobro ohranjen primerek.

Problematična je vrsta *Nummulites boussaci* Rozlozsnik iz spodnjega horizonta v Paprati (Pavlovec & Klepač, 2003). Po višini zavojev je bližja vrsti *N. praelorioli*, kar ustreza tudi starosti spodnjega horizonta v Paprati. Po velikosti hišic je numulit iz Paprate bliže vrsti *N. boussaci*, saj doseže velikost do 23 mm. Prav možno je, da je med vrstama *N. praelorioli* in *N. boussaci* vmesna oblika, ki ji pripadajo tudi nekateri primerki iz Paprate. Za rešitev tega vprašanja nimamo dovolj materiala.

Nummulites perplexus Schaub, 1981

1981. *Nummulites perplexus* nov. sp. – Schaub, 132–133, tab. 4 e, tab. 39, sl. 1–13, 16–25

2003. *Nummulites perplexus* Schaub, 1981 – Pavlovec & Klepač, 212–213

Mikrosferična generacija

Hišica je lečasta, proti sredini se počasi debeli in ima precej neraven rob. Površina je prekrita z gostimi, meandrirajočimi linijami. Zavoji, ki jih je od 25 do 26, so nizki. Najvišji so v srednjem delu hišice, proti zunanjemu robu se močno nižajo. Septa so gosta, nagnjena in malo usločena. Premeri hišic so med 17 in 25 mm, po Schaubu (1981) med 15 in 26 mm (napačno navedeno med 1,5 in 2,6 mm).

Vrsta *N. perplexus* je bila v zgornjem horizontu pri Paprati in v naših krajih sploh najdena prvič (Pavlovec & Klepač, 2003). Znana je iz Italije in Libije v spodnjelutetijskih plasteh.

STAROST PLASTI PRI PAPRATI

Spodnji horizont

Assilina maior maior je živela v zgornjem cuisiju in na bazi lutetija, *A. maior punctulata, A. cuvillieri, A. suteri* in *Nummulites campesinus* so zgornjecuisijski. *A. suteri* je znana iz vrha cuisija in iz spodnjega lutetija. Numulit, ki kaže na vmesne znake med zgornjecuisijskim in spodnjelutetijskim *N. praelorioli* in srednjelutetijskim *N. boussaci,* se zdi bližji vrsti *N. praelorioli.* Spodnji horizont v Paprati je torej zgornjecuisijski, vendar blizu meje cuisij- lutetij.

Zgornji horizont

A. spira abrardi, N. verneuili, N. obesus in *N. perplexus* so spodnjelutetijski. *A. suteri, N. praelorioli* in *N. lehneri* so znani iz spodnjega lutetija in najvišjega cuisija. Nekatere asiline iz Paprate so podobne primerkom *A.* aff. *maior,* ki jih ima Schaub (1981) za prehod med podvrstama *A. maior maior* in *A. spira abrardi.* Nekateri numuliti, ki jih označujemo kot *N.* aff. *verneuili,* spominjajo na zgornjecuisijski obliki *N. friulanus* in *N.* aff. *lehneri* sensu Schaub 1981. Tudi primerek, podoben spodnjelutetijski vrsti *N. lehneri*, je blizu Schaubovim primerkom *N.* aff. *lehneri* iz vrha zgornjega cuisija pri Haymani v Turčiji.

Po vsem tem sklepamo, da je zgornji horizont pri Paprati iz starejšega dela spodnjega lutetija in da med spodnjim in zgornjim horizontom ni večje časovne razlike.

THE NUMMULITINS FROM THE PAPRATA LOCALITY ON THE ISLAND OF KRK (CROATIA)

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SUMMARY

Although the nummulitins of the Island of Krk are quite common in limestones and clastites, no true biocenoses have survived there. With regard to the classification of nummulitin localities, the original biocenosis in limestones of the primary localities is somewhat changed (type 1a: after Pavlovec, 2003). In flysch and other clastites, the nummulitins always occur in the secondary place (type 3a; after Pavlovec, 2003).

At the Paprata site, which lies between the villages of Dobrinj and Vrbnik in the eastern part of the island, the nummulitins occur in two horizons. In the older beds, the Assilina maior maior, A. maior punctulata, A. cuvillieri, A. suteri *and* Nummulites campesinus *are located, while the upper horizon holds* A. spira abrardi, A. *aff.* maior (*after Schaub 1981 a transition between* A. maior maior *and* A. spira abrardi), N. verneuili, N. obesus, N. lehneri *and* N. praelorioli. *The lower horizon is Upper Cuisian, close to the Cuisian-Lutetian boundary. The upper horizon consists of the older part of the Early Lutetian. Between the two Paprata horizons, there is therefore no major time span.*

Key words: nummulitins, Eocene, Krk Island, Croatia

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SELŠKE NIZKOMETAMORFNO-VULKANSKO-SEDIMENTNE PLASTI, OSREDNJA SLOVENIJA

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IZVLEČEK

Ozemlje Selške doline in njenega obrobja grade mezozojske in paleozojske kamnine. Med njimi so daleč najbolj razširjene pestro razvite pisane ladinijske kamnine, ki druga v drugo prehajajo bočno in v navpični smeri že na kratke razdalje, kar je posledica živahne tektonske dejavnosti, vulkanizma in dejstva, da to ozemlje leži na pregibu med Dinarsko karbonatno platformo in Slovenskim bazenom. Ladinijske kamnine leže erozijsko in diskordantno na anizijskem dolomitu ali pa so v tektonskem kontaktu s sosednjimi kamninami. V krovnini so klastične in piroklastične kamnine psevdoziljskega faciesa.

Ključne besede: stratigrafija, litostratigrafska razčlenitev, petrografija, srednji trias, zahodne Posavske gube

STRATI BASSO-METAMORFICO-VULCANICO-SEDIMENTARI DI SELCA, SLOVENIA CENTRALE

SINTESI

La valle di Selca e le terre circostanti sono costituite da formazioni paleozoiche e mesozoiche. Tra queste le più comuni sono le eterogenee, variegate rocce ladiniane che sfumano una nell'altra lateralmente e verticalmente già entro brevi distanze, il che è conseguenza delle attività tettonica e vulcanica e del fatto che tale area è situata al margine tra la piattaforma carbonatica dinarica e il bacino sloveno. Le rocce ladiniane giacciono sulla dolomite anisiana e sono in contatto tettonico con le rocce circostanti. Il tetto di faglia è rappresentato da rocce clastiche e piroclastiche della facies pseudosiliana.

Parole chiave: stratigrafia, smembramento litostratigrafico, petrografia, triassico medio, pieghe occidentali della Sava

UVOD

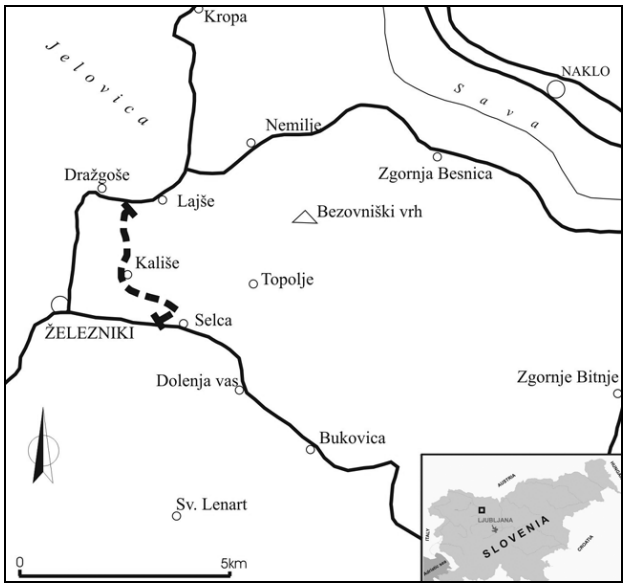
V zahodnih Posavskih gubah sva za študij stratigrafije in litostratigrafsko razčlenjevanje ladinijskega zaporedja plasti izbrala profil na severnem obrobju Selške doline med Selcami in Kališami (Sl. 1).

V geotektonskem pomenu pripada raziskano ozemlje Posavskim gubam oziroma Dinaridom, v geografskem pa Škofjeloškemu hribovju. Pionirske geološke raziskave na obravnavanem ozemlju so opravili Kossmat (1898, 1903, 1910), Kossmat & Diener (1910) ter Heritsch (1934). Geološka zgradba tega ozemlja je bila najbolj vsestransko in sistematično raziskana in opisana med regionalnim geološkim kartiranjem za Osnovno geološko karto SFRJ na listu Kranj (Grad & Ferjančič, 1974, 1976). Triasni vulkanizem na Slovenskem so opisali Rakovec (1946), Duhovnik (1956) ter Grafenauer *et al.* (1983). Zelene skrilavce in spilitizirane kamnine v Sloveniji je raziskovala Hinterlechner (1959), Hinterlechner-Ravnik (1978). Ozemlje, ki ga obravnavamo, zajemajo v najnovejšem času detajlne geološke raziskave za Geološko karto Slovenije M 1:50 000, ki jih opravlja Geološki zavod Slovenije.

V Selški dolini in njeni okolici je med mezozojskimi kamninami najbolj pestro razvito in najmanj raziskano zaporedje nizkometamorfno-vulkansko-sedimentnih kamnin, kjer pisane kamnine druga v drugo prehajajo bočno in v navpični smeri že na kratke razdalje. Naš namen je, da te kamnine petrografsko opišemo, določimo njihovo stratigrafsko lego in način vključevanja v sosednje kamnine, čim podrobneje litostratigrafsko razčlenimo, s fosili, po stratigrafski legi in sedimentoloških značilnostih pa ugotovimo njihovo starost in okolje nastanka. Glavni namen tega članka je, da opišemo sedimentno petrografske značilnosti tipičnih kamin ladinijske starosti in da te plasti nadrobno litostratigrafsko razčlenimo.

MATERIAL IN METODE

Geološki podatki, ki so uporabljeni za ta članek, so bili pridobljeni med regionalnim geološkim kartiranjem za Osnovno geološko karto Slovenije M 1:100 000 predvsem z metodo vseh golic in med geološkim kartiranjem za Geološko karto Slovenije M 1:50 000, kjer je prevladovala metoda profiliranja. Najnovejše podatke sva dobila pri stratimetrijskem profiliranju. Vzporedno z geološkim kartiranjem so potekala vzorčevanja kamnin in laboratorijske raziskave. Petrografske analize nabranih kamnin je napravila Hinterlechner-Ravnik. Karbonatne kamnine so določene po Folkovi (1959) in Dunhamovi (1962), klastične pa po Pettijohnovi (1975) klasifikaciji.



Sl. 1: Lega raziskanega profila in ozemlja.
Fig. 1: Location of the investigated cross-section and the study area.

STRATIGRAFIJA

Ladinij

Ladinijske plasti smo detajlno raziskali in litostratigrafsko razčlenili na severnem obrobju Selške doline v profilu med Selci in Kališami (Tab. 1).

PROFIL SELCA – KALIŠE

Selške nizkometamorfno-vulkansko-sedimentne plasti

Selške nizkometamorfno-vulkansko-sedimentne plasti so razširjene na severnem obrobju Selške doline. Razprostirajo se na prostranem območju med Lajšami, Selci in Dolenjo vasjo, od tam pa se nadaljujejo prek Topolj, Zabrekev in Brezovniškega vrha do Hrastovega roba in grape Male Besnice.

Sestavljajo jih nizkometamorfni skrilavci ter vulkanske, piroklastične, klastične in karbonatne kamnine. V spodnjem delu prevladujejo nizkometamorfni skrilavci, v zgornjem pa predornine. Po litološki sestavi in superpoziciji sva celotni kompleks razdelila v štiri litostratigrafske enote, in sicer: 1 – bazalni konglomerat, 2 – facija zelenih skrilavcev z lečami apnenca, 3 – kompleks sericitnih skrilavcev, kislih predornin in sedimentnih kamnin, 4 – kompleks bazičnih kamnin.

Tab. 1: Litostratigrafska razčlenitev selških nizkometamorfno-vulkansko-sedimentnih plasti.
Tab. 1: Lithostratigraphic dismembering of the Selca Low Metamorphic-Volcanic-Sedimentary Beds.

FORMACIJA / FORMATION	STAROST / AGE	ENOTE / UNITS	DEBELINA / THICKNESS (m)	FACIJE IN KOMPLEKSI / FACIES AND COMPLEXES
Selške nizkometamorfno – vulkanogeno - sedimentne plasti / Selca Low Metamophic – Volcanic - Sedimentary Beds	LADINIJ / LADINIAN	4.	50–80	Kompleks bazičnih kamnin / Complex of mafic rocks
		3.	100–150	Kompleks sericitnih skrilavcev, kislih predornin in sedimentnih kamnin / Complex of sericite schists, acid volcanic and sedimentary rocks
		2.	30–40	Facija zelenih skrilavcev z lečami apnenca / Greenschists facies with lenses of limestone
		1.	10–20	Bazalni konglomerat / Basal conglomerate

Bazalni konglomerat

Kontakt nizkometamorfno-vulkanogeno-sedimentnega zaporedja z anizijskim dolomitom je razkrit na več mestih med Špičastim hribom in Potoško grapo, kjer leže kamnine obravnavanih plasti transgresivno na plastnatem in masivnem dolomitu, lateralno pa na temnosivem dolomitiziranem in lapornem apnencu. Na samem kontaktu se tu in tam pojavlja bazalni konglomerat s slabo zaobljenimi prodniki anizijskega dolomita, ki prehaja navzgor v konglomerat s kosi temnosivega sparitnega apnenca, dolomitiziranega apnenca in dolomita. Vmes so leče vijoličastega lapornega skrilavca in glinavca. Konglomerat je slabo sortiran in ponekod prehaja v konglomeratični peščenjak. Vezivo konglomerata je laporno, peščeno in glineno. Največkrat je bolj ali manj hematitizirano. Konglomerat ne vsebuje fosilnih ostankov. Najverjetneje se je usedal na območju rečnih delt. Na starost konglomerata lahko sklepamo le po njegovi stratigrafski legi. Grad & Ferjančič (1974, 1976) sta menila, da pripada fassanski podstopnji.

Facija zelenih skrilavcev z lečami apnenca

Zeleni skrilavci. V to enoto uvrščamo filitom podobne nizkometamorfne temnozelene kamnine, ki so nastale pri regionalni metamorfozi vulkanskih kamnin, njihovih tufov in sedimentov. Zeleni skrilavci (Sl. 2) vsebujejo obilico zelenih mineralov, kot so klorit, epidot, ki so nastali pri regionalnem in kataklastičnem (dislokacijskem) metamorfizmu in nastajajo v glavnem pod vplivom enostranskih, usmerjenih pritiskov. Usmerjeni pritiski so povzročili nastanek večje ali manjše skrilavosti kamnin in rušenje prvotne strukture mineralov. K zabrisanju prvotne strukture in tekstur kamnin je prispevala tudi metamorfna kristalizacija. Plagioklaz v obravnavanih metamorfnih kamninah je nizkotemperaturni albit. Zeleni skrilavci nastajajo pri regionalnem in dislokacijskem metamorfizmu pri nizkih temperaturah in nizkih hidrostatičnih pritiskih iz bazičnih kamnin in njihov tufov. Pri nizkotemperaturni metamorfozi so poleg naštetih sprememb najpogostnejše in najbolj značilne spremembe albitizacija, kloritizacija in kalcitizacija.

Leče apnenca. V temnozelenem in temnosivkastozelenem metamorfoziranem skrilavcu v profilu Selca-Kališe se pojavljajo tanke (1–10 cm) leče zelenkastosivega mikritnega apnenca s številnimi kalcitnimi žilicami in žilami (0,5–2 cm).

Kompleks sericitnih in kloritnih skrilavcev, kislih predornin in sedimentnih kamnin

Tretja litostratigrafska enota nizkometamorfno-vulkansko-sedimentnega kompleksa v Selški dolini sestoji iz zaporedja sericitnih in kloritnih skrilavcev, kislih predornin in njihovih tufov, dveh vložkov apnencev ter tufita in peščenjakov.

Sericitni in kloritni skrilavci. V tretji litostratigrafski enoti prevladuje svetlosivi do beli in (če so limonitizirani) rjavkasti in rumenkasti sericitni skrilavci ter svetlozelenkastosivi do zelenkasti kloritni skrilavci. Nastali so v razmerah močnih usmerjenih pritiskov (dislokacijski metamorfizem) in intenzivnih hidrotermalnih sprememb. Kamnino sekajo pogosto tanke žilice, zapolnjene z drobnimi idiomorfnimi zrnci kalcita. Kamnina je največkrat bolj ali manj skrilava. Skrilavci sestoje iz nekaj desetink milimetra velikih mikrokristalnih drobcev. Ti so podolgovati in zaobljeni. Njihova oblika je posledica kataklaze. Ne kažejo nobene strukture. Sestavljeni so iz mikrokristalnega kremena, kalcita in sericita. Zelo redki so močno albitizirani plagioklazi, ki imajo enako obliko kot litoidni drobci. Osnova je enake sestave kot drobci. Ploskve skrilavcev so zaradi kaolinizacije zelo dobro vidne. Večina drobcev je verjetno tufskega izvora; navadno so močno sericitizirani in kalcificirani.

Sl. 2: Selca – Kališe: nagubane plasti facije zelenih skrilavcev.
Fig. 2: Selca – Kališe: folded beds of the greenschist facies.

Semischisti so svetlozelene, s posameznimi belimi in temnosivimi zrni močno skrilave kristalinske kamnine, ki so nastale med dinamično metamorfozo in jih zlahka koljemo v tanjše in zelo tanke plošče predvsem zaradi paralelne usmerjenosti več kot 50% mineralov, še zlasti tistih z lamelarno ali podolgovato prizmatsko obliko, kot sta sljuda in rogovača. V glavnem gre za kataklazirane tufe kisle magmatske magme. Ob prvotnih vtrošnikih opazujemo lečaste odebelitve, ki jih oblikujejo vtrošniki in osnova pred zrnom in za njim, ki so pomenili oviro. Odebelitve so paralelne skrilavosti kamnine, večji vtrošniki pa so subparalelno orientirani. Ta lega morda ponazarja sled usedanja tufa. Po ploskvah skrilavosti je kamnina deloma limonitizirana. Kamnina je kompaktna in slabo skrilava. Megaskopsko vidimo 1-2 mm velika bela zrna kaoliniziranih glinencev. Sestavljena je iz kloritizirane mikrokristalne silikatne osnove, plagioklaza, kremena in neprosojnih kovinskih zrn (akcesorno).

Struktura je kataklastična, porfirska. Osnova je mikrokristalna, silikatna in sericitizirana. Vtrošniki pripadajo plagioklazu in kremenu. Plagioklazi so večinoma spremenjeni (kaolinizirani in sericitizirani). Le na redkih zrnih vidimo, da so kisle sestave, oziroma da pripadajo K–glinencu. Kremen potemnjuje enotno.

Kamnina je nastala z istočasnim odlaganjem pelitskega materiala, ki je verjetno sedimentnega izvora (vsaj deloma) in večjih zrn kremena ter plagioklaza, ki so vulkanskega izvora.

Skrilavi peščenjak. Kamnina je tufskega izvora, saj vsebuje litoidne drobce (70%) in plagioklaze (20%). Plagioklazi pripadajo albitu, nekateri tudi K-glinencem. Včasih so nadomeščeni z drobnimi bolj ali manj kaoliniziranimi plagioklazi. Litoidni drobci so močno kaolinizirani in slabo prosojni. Sericitne in kloritne luske v njih so paralelno usmerjene. Kremena je zelo malo. Vsi drobci so presedimentirani (nalomljena zrna). Osnove je vsega 10%. Vezivo je kontaktnega tipa, mikrokristalno in sericitizirano. Struktura je srednjezrnata, tekstura pa skrilava.

Albitizirani keratofirski litoklastični tuf je kompaktna kamnina temnosive barve z belimi zrni. Sestavljena je iz osnove, plagioklazov, klorita, limonita in muskovita (sericita). V kamnini prevladuje mikrokristalna osnova, ki sestoji iz polprosojne glinene snovi in klorita. Vsebuje tudi nekaj stotink mm velike vtrošnike plagioklazov. V osnovi so številna večja idiomorfna in hipidiomorfna zrna plagioklazov, ki so močno spremenjena – kaolinizirana. Dvojčični in lamelarni plagioklazi so najpogosteje kataklazirani, pripadajo pa albitu, ki je verjetno sekundaren. Struktura je porfirska.

Presedimentirani tuf. Gre za svetlozeleno, kompaktno in nekoliko skrilavo kamnino kisle magmatske sestave, v kateri prevladujejo nekoliko kloritizirana mikrokristalna osnova in plagioklazi, nekaj pa je tudi klorita, kovinskih zrn in limonitne impregnacije. Plagioklazi so hipidiomorfni, le redki so idiomorfni. Kamnina je večino-

ma spremenjena, se pravi kloritizirana in sericitizirana. Nekateri plagioklazi so popolnoma kaolinizirani. Neprosojna kovinska zrna so združena v skupke in pripadajo limonitiziranemu piritu.

Tufit s psamitsko strukturo je precej kompaktna in zrnata kamnina svetlozelene barve. Sestavljajo ga kamninski drobci (70%), plagioklazi (10%), 3% klorit, 15% kremen, 2% K glinenec, osnova in neprosojna kovinska zrna. Osnova je mikrokristalna. Neprosojna kovinska zrna in kloritna zrna merijo od nekaj stotink mm do 2,0 mm, zrna plagioklazov in kremena od 0,1 do 1 mm (prevladujejo 0,2–0,3 mm zrna), kamninski drobci pa 0,2 mm do 1,1 mm. Plagioklazi, K-glinenci in kremen so hipidiomorfni. Struktura je grobozrnata. Osnova je mikrokristalna, silikatna in kloritizirana. Kamninski drobci so silikatni. Pogosto so delno kloritizirani. Nekateri imajo fluidalno strukturo. Vsebujejo tudi neprosojna kovinska zrna. Plagioklazi so večinoma spremenjeni, kaolinizirani, le redki so sveži. Pripadajo oligoklaz-andezinu. Na zrnih K-glinencev opazujemo pertsko strukturo.

Litoklastični in kristaloklastični keratofirski tuf je svetlozelena kamnina, sestavljena iz litoidnih vulkanskih drobcev, drobcev plagioklaza in mikrokristalnega veziva. Velikost zrn je od nekaj stotink mm do nekaj mm. Vezivo je silikatno, kontaktnega tipa. Del drobcev je zaobljen, večina pa je nezaobljenih. Kamnina je precej sericitizirana. Nekateri drobci so prosojni, drugi močno kaolinizirani in skoraj neprosojni. Tudi glinenci so večinoma spremenjeni oziroma kaolinizirani in albitizirani.

Drobnozrnati tufski peščenjak je močno podoben sericitnemu in kloritnemu skrilavcu. Sestavljen je iz mikrokristalnih litoidnih fragmentov, ki večinoma merijo nekaj desetink mm in le redko 1 mm. Vezivo je mikrokristalno, sericitno-kloritno-glinasto, kontaktnega in ponekod bazalnega tipa. Sestava kamnine je kisla (keratofirska). Posamezni drobci so nekoliko zaobljeni (intraformacijsko presedimentirani), drugi so popolnoma oglati, zlasti večji. Litoidni drobci so mikrokristalni in ponekod bolj prosojni kot osnova. Luskice v njih so paralelno orientirane, ustrezno orientaciji drobcev. Plagioklazi pripadajo albitu. Poleg albitizacije je opazna tudi sericitizacija. Po obliki so idiomorfni, hipidiomorfni ali združeni v skupke.

Lapilni tuf sestavljajo do 6 cm veliki drobci vulkanskih kamnin verjetno iz kremenovega keratofirja. V večjem delu kamnine opazujemo fluidalno strukturo, ki jo sekajo drobne kremenove žilice. Lapilni tuf je zelenkastosiv, pri čemer so različni fragmenti različno intenzivno zeleni. V kamnini prevladujejo večji in manjši vtrošniki plagioklaza, ki pripadajo večinoma albitu, redko tudi K-glinencu. Nekateri vtrošniki so sveži, drugi pa močno kaolinizirani ali kloritizirani. Nekateri drobci pripadajo verjetno bazičnim kamninam. Drobci so ostri in se med seboj dotikajo. Vmes med njimi ni videti veziva. Komponente tvorijo usmerjeno fluidalno teksturo.

Sl. 3: Selca – Kališe: temnosivi ploščasti apnenec spodnjega apnenčevega horizonta.
Fig. 3: Selca – Kališe: the dark gray platy limestone of the lower limestone horizon.

Skrilavi pelitni tuf je svetlozelena kompaktna in skrilava kamnina podobna zelenosivemu tufskem skrilavcu. Sestavljena je iz mikrokristalne silikatne in sericitne osnove, kremena in redkih kaoliniziranih zrn. Zrna so razpotegnjena v smeri skrilavosti. Sericit je lepo kristaliziran. Kremenova zrna imajo nepravilno obliko in so enotno potemnjena.

Kremenov keratofir je kompaktna in pogosto skrilava predornina svetlosive do sive barve. Po ploskvah skrilavosti je zaradi limonitizacije rjavkast, ob razpokah pa rjav. Sestavljen je iz osnove, sericita, kremena, neprosojnih kovinskih zrnc, limonitnih impregnacij in redkih lusk muskovita. Mikrokristalna osnova je pod pritiskom postala skrilava. Ob večjih motnih vtrošnikih kremena se je osnova nagubala in nastale so lečaste odebelitve. V kamnini prevladuje mikrokristalna silikatna osnova. Tudi sericit, ki se pojavlja v mikroplasteh, je mikrokristalen. Neprosojna kovinska zrnca so velika do 0,1 mm, kremen kot vtrošnik in drugi vtrošniki pa imajo premer od 0,1–1 mm. Struktura kamnine je kataklastična in porfirska. Zrna kremena so hipidiomorfna. Pogosto so magmatsko korodirana, potemnjujejo pa enotno.

Vložki in leče apnenca. Podobno kot v drugi so tudi v tretji litostratigrafski enoti tanjši vložki in leče apnenca. Najpomembnejši je debelejši horizont apnenca, ki se pojavlja na južnem, jugovzhodnem in jugozahodnem pobočju hriba Goverovna severovzhodno od Selce (Sl. 3). Apnenec je srednjesiv s sparitno strukturo in spremenljivo debelino plasti, od 10 cm do 200 cm. Tu in tam je laminiran. Največjo debelino – 25 do 30 metrov – doseže na južnem grebenu Goverovne. Proti severozahodu se nato razcepi v dva tanjša horizonta, proti severovzhodu pa se južno od Topolj izklini. Podoben apnenec se pojavlja tudi na zahodnem pobočju Blegoša južno od Pozirna in v Dolenji vasi v strugi Selške Sore.

Sl. 4: Selca – Kališe: zgornji horizont apnenca pripada plastnatemu sparitnemu apnencu.
Fig. 4: Selca – Kališe: the upper limestone horizon belongs to the bedded sparitic limestone.

V zgornjem delu nizkometamorfno-vulkansko-sedimentnega zaporedja so manjši pojavi apnenca pod Rosovim kopišem nad dolino Besnice. Tam se pojavljata dve leči apnenca z debelino 5 do 7 metrov oziroma 3 do 4 metre. Apnenec je srednjesiv s slabo izraženo plastnato teksturo. Po strukturi je spariten (Sl. 4); ponekod je precej silificiran in laminiran.

Fosilni ostanki v teh kamninah so redki. V apnencu, ki se pojavlja med vulkanogenimi kamninami med Selco in Kališami, so bili najdeni konodontni elementi sledečih oblikovnih vrst: *Neogondolella trammeri* (Kozur), *Neogondolella transita* (Kozur & Mostler) in *Neogondolella* sp. Konodontni elementi dokazujejo ladinijsko starost te enote.

Filoniti. Drobnozrnate filitom podobne kamnine z močno izraženo foliacijo in z značilno lečasto teksturo, ki so nastali pri drobljenju zrn debelozrnatih magmatskih in metamorfnih kamnin ob močnih dislokacijah in pri spremljajoči rekristalizaciji, smo uvrstili med filonite.

Pri teh procesih nastopa regresivni metamorfizem. Primarni minerali vse bolj zgubljajo svoje značilnosti. Vse pa se konča z milonitizacijo kamnine, ko so minerali neprepoznavni. Filoniti so močno skrilave kamnine. Po površini se lesketajo drobne luskice sericita in klorita, ki so se tu nakopičile pri omenjeni metamorfozi muskovita in drugih sljud. Na obravnavanem območju so filonitizirane predvsem kamnine kisle sestave, kot so kremenov keratofir in njegovi tufi. Svetlosiva in zaradi limonitizacije rjava filonitizirana kamnina je sestavljena iz mikrokristalne osnove od 0,1 do 0,3 mm velikih kamninskih drobcev, plagioklazov ter neprosojnih kovinskih zrnc. Sericitno-kremenova osnova je pod pritiskom postala skrilava. Ob redkih prvotnih vtrošnikih opazujemo skrilavosti paralelne brečaste odebelitve. Redki večji vtrošniki so subparalelno orientirani. Po ploskvah skrilavosti opazujemo sericitni lesk. V kamnini prevladujejo v smeri skrilavosti razpotegnjeni kamninski drobci. Večinoma so silikatni ter mikro do kriptokristalni. Osnova je sericitna in rahlo limonitizirana. Neprosojna kovinska zrna so združena v skupke, ki so razpotegnjena v smeri skrilavosti, pripadajo pa limonitiziranemu piritu.

Kompleks bazičnih kamnin

Kompleks bazičnih kamnin sestoji iz plitvih bazičnih intruzivov, izlivnih predornin, spilitiziranih bazičnih kamnin in njihovih tufov. Med bazičnimi kamninami so ugotovljeni spilitizirani diabaz, bazalt, bazični porfirit in diabazni tufi. Bazične kamnine so precej redkejše od kislih.

Največje nahajališče naštetih kamnin v tem delu Slovenije leži na severnem robu Selške doline med Selco in Lajšami. V Škofjeloškem hribovju se te kamnine pojavljajo še v okolici Žetine, na vznožjih Malenskega vrha in vzhodno od Blegoša. Ohranjene so še med zgornjim delom grape Selnice in Zabrekvami ter na majhnem območju Šmetinca od doline Besnice.

Diabaz. Ta kompaktna ter pogosto skrilava in luknjičava bazična kamnina, prepredena z belimi kalcitnimi žilicami (Sl. 5), je temnozelena do temnosiva (Sl. 6) z drobnimi svetlozelenimi, temnozelenimi in rjavimi geodami. Sestavljena je iz mikrokristalne osnove, bazičnih plagioklazov, klorita, avgita, kremena, kalcita in zrnc neprosojnih kovinskih mineralov. Osnovo kamnine sestavljajo mikrokristali plagioklazov, medprostore pa izpolnjujejo različni femični minerali ali vulkansko steklo. Vulkansko steklo je pogosto nadomeščeno s kloritom, albitom, sericitom, kalcitom ali z železovimi oksidi. Struktura je intersertalna in ofitska s prehodi v porfirsko, mandljasto in fluidalno. Kamnina v glavnem sestoji iz plagioklazov avgita in klorita. Plagioklazi so paličasti in hipidiomorfni; pripadajo albitu in oligoklaz andezinu. Nastopajo posamezni in dvojčični plagioklazi. Pogosto so albitizirani in kaolinizirani. Avgit je večinoma kloritiziran. V spilitu so vtrošniki nizkotemperaturnega albita.

V kamnini so tudi številne drobne geode. To so od nekaj desetink mm do 2 mm, redko do 1 cm velike votlinice plinskih mehurčkov, zapolnjene večinoma z zrni kalcita, klorita ali kremena, redkeje z limonitom ali z zrni epidota. Še redkeje so geode zapolnjene z diabazi kasnejših erupcij. Celotna geoda je včasih zapolnjena z enim samim kristalom kalcita. Klorit, epidot in včasih kalcit ali kremen v geodah so mikrokristalni. Mnoge geode, še zlasti pa tiste, ki so zapolnjene z limonitom, so izlužene oziroma prazne. Rob geode kaže ponavadi drugačno strukturo kot preostala kamnina. Sestavljen je iz mikrokristalnega kremena, kalcita ali žarkovito vlaknatega klorita. Geode so včasih sploščene in potekajo vse v isto smer, kar daje videz fluidalne ali mandljaste strukture. Od ostale kamnine se ločijo po svetlejši zeleni, rdečkasti, rjavi ali beli barvi in po strukturi. Poleg na-

štetega vsebuje diabaz še večji ali manjši odstotek od nekaj stotink mm do nekaj desetink mm velikih zrn neprosojnih kovinskih mineralov, ki večinoma pripadajo železovima mineraloma ilmenitu in magnetitu.

Bazalt. Ta bazična vulkanska kamnina je temnozelenosive do sivkastočrne barve. Pogosto je kompakten in bolj ali manj skrilav. Vzporedno s ploskvami skrilavosti se v njem pojavljajo pasovi vijoličaste barve. Skrilavost kamnine je izražena predvsem s kristalizacijo filosilikatov, ki nadomeščajo nekdanjo osnovo. Bazalt ima porfirsko ali steklasto strukturo, pogosto pa se tudi v tej kamnini pojavljajo mandlji oziroma geode, zapolnjene s sekundarnimi minerali, predvsem pa s kloritom. Bazalt je sestavljen iz bazičnih plagioklazov, avgita, včasih olivina, rogovače in hiperstena. Zanj je značilna porfirska struktura.

Bazalt in diabaz sta spremenjena v tolikšni meri, da pripadata že metamorfnim kamninam, t.j. faciesu zelenih skrilavcev. Prvotno vulkansko steklo in pirogene minerale nadomeščajo sekundarni minerali, zato so te kamnine pogosto precej skrilave.

Spilit. V razmerah dolgotrajnih visokih pritiskov in kemičnih sprememb so kamnine iz bazaltne lave na obravnavanem ozemlju bolj ali manj spremenjene. Za spilitizacijo teh kamnin je najbolj značilna albitizacija prvotno visokotemperaturnih bazičnih plagioklazov. Pri izredno močni albitizaciji nastane iz bazaltne lave, ki je obogatena z vodo (submarinske razmere), spilit. Albitizacijo spremljajo še druge spremembe, kot so sericitizacija, kalcifikacija, silifikacija in epidotizacija. Spiliti so torej sestavljeni iz nizkotemperaturnega albita, klorita, epidota, avgita, levkoksena, sericita in kalcita.

Spilitizirani diabazni tuf. Tudi ta kamnina je intenzivno temnozelena, popolnoma spremenjena, drobnozrnata in skrilava. Podobna je torej matični predornini. V njeni sestavi prevladuje mikrokristalna osnova s plagioklazi. Podobno kot pri predorninah iz bazične lave opazujemo tudi v tufu zelo močne spremembe, kot so kloritizacija, sericitizacija in kalcitizacija.

RAZPRAVA

V podlagi obravnavanega zaporedja ladinijskih plasti leži na raziskanem ozemlju anizijski dolomit. Ob koncu anizijske dobe se je ozemlje ob zahodnem robu Posavskih gub pod vplivom povečanega delovanja epirogenetskih sil dvignilo. Nastalo je lokalno kopno, ki je bilo tektonsko razkosano in izpostavljeno eroziji. Erodiran je zgornji del anizijskega dolomita, ki je dal material za bazalno ladinijsko dolomitno brečo in konglomerat. Erozija je segala ponekod tudi v skitske kamnine, saj sestavljajo plasti zgornjega dela konglomerata kosi in prodniki skitskih kamnin, ki so v različni meri zaobljeni. Konglomerat ponekod prehaja bočno v brečo in heterogen apnenčev peščenjak s tufsko primesjo. Osnova je najpogosteje sestavljena iz mikrokristalnega kalcita, redkeje iz dolomita in sericita. Meja med anizijskimi in ladinijskimi kamninami ima značaj kotne tektonsko-erozijske diskordance, podobno kot sta to ugotovila na idrijskem ozemlju Mlakar (1967) in Čar (1990). Da je med starejšimi kamninami in konglomerati erozijska diskordanca, je opazil že Kossmat (1898). Konglomerate v ladinijskih plasteh omenja tudi Kropač (1912). Pri Zavratcu je v konglomeratu odkril tufske in skrilave vložke ter odtise školjk *Posidonia wengensis* Wissmann in *Daonella lommeli* Wissmann.

Ladinijski litološki stolpec Selške doline in njegove posamezne litološke dele lahko primerjamo z razvoji ladinijskih plasti na listih Postojna (Pleničar *et al.*, 1970), Kranj (Grad & Ferjančič, 1976) in Celovec (Buser, 1980a), z idrijskim ozemljem (Berce, 1962; Buser, 1979; Mlakar, 1967, 1969; , Jurkovšek, 1984; Čar, 1990) ter z

Sl. 5: Selca – Kališe: diabaz z belimi kalcitnimi žilicami.
Fig. 5: Selca – Kališe: diabase with white calcite veinlets.

Sl. 6: Selca – Kališe: temnosivi diabaz.
Fig. 6: Selca – Kališe: dark grey diabase.

območji Jagršče-Želin (Bavec, 1999), Sredniška grapa pod Križno Goro (Demšar & Dozet, 2003) in Stopnik-Šebrelje-Šebreljski vrh (Čar & Skaberne, 1995, 2003). Pleničar *et al.* (1970) so v ladinijski skladovnici razlikovali skonca plasti, na katerih leži pisan apnenodolomitni konglomerat in ploščasti apnenec z roženci na vrhu. Ugotovili so, da glede na razvoj in neznačilno makrofloro uvrstitev teh sedimentov med psevdoziljske plasti ni utemeljena. Na območju Idrije-Rovte so Berce *et al.* (1960) predstavili "psevdoziljske sklade" kot zgornji del wengenskih skladov. Sestoje iz črnega glinenega skrilavca in peščenjaka. V njih ni vložkov tufa, kar si razlagajo z večjo oddaljenostjo od vulkanskih središč. Tektonska premikanja v srednjem triasu je dokazal že Kossmat (1936). Uvrstil jih je v ladinijsko tektonsko fazo. Berce (1963) je te premike pripisal srednjetriasni predladinijski orogenezi. Grad & Ferjančič (1976) sta v ladinijski stopnji razlikovala konglomerat in peščenjak ter piroklastite in apnenec, ki navzgor prehaja brez prekinitve sedimentacije v masiven, izrazito kristalast in luknjičast cordevolski dolomit z algami *Diplopora annulata* Schafhäutl, *Teutloporella nodosa* Schafhäutl ter *Teutloporella triasina* Schauroth. V evgeosinklinalnem delu Tetide je močna vulkanska dejavnost botrovala nastanku keratofirsko spilitnih kamnin in piroklastitov. Pojavljajo se kisli in bazični diferenciati, ki prehajajo drugi v druge. Med kisle in srednje kisle magmatske kamine so uvrščeni keratofir, porfir, kremenov porfirit, njihovi piroklastiti ter sericitni skrilavec, k bazičnim magmatskim kamninam pa so prišteti diabaz, spilit, njihovi tufi in kloritni skrilavec. Psevdoziljske skrilavce, katerih nastanek je v tesni zvezi z vulkansko dejavnostjo, je treba jemati kot posebno formacijo evgeosinklinalnega dela Tetide. Leže konkordantno na selških plasteh, navzgor pa prehajajo prav tako brez vidnih znakov prekinitve sedimentacije v Kossmatove (1910) amfiklinske sklade. Med psevdoziljskimi in amfiklinskimi skladi razen v tem, da prvi vsebujejo vložke tufov, ni posebnih litoloških razlik. Na listu Celovec (Buser, 1980a) je posebno zanimiv ladinijski pisani konglomerat med Podljubeljem, Jelendolom in Vetrh vrhom ter v okolici Ljubelja, ki leži največkrat na rjavkastem ladinijskem laporju. Pretežno masiven nesortiran konglomerat sestoji iz prodnikov trogkofelskih, grödenskih, skitskih in ladinijskih kamnin. Vezivo je sestavljeno iz karbonatnega drobirja in veliko limonita. V konglomeratu so vložki peščenjaka, glinavca in tufa. Enači ga z ugoviško brečo. Na listu Tolmin in Videm (Buser, 1986) so v ladiniju na območju Zunanjih Dinaridov tufi, laporovci in ploščasti apnenci s preboji in medplastovnimi izlivi kremenovega keratofirja, porfirja in diabaza, na območju Notranjih Dinaridov pa glinasti skrilavec, drobe, tuf s preboji keratofirja in porfirja. Litološko in starostno jih primerja s psevdoziljskimi skladi. V Zunanjih Dinaridih so v naštetih plasteh daonele, ki kažejo na langobard, v Bohinju pa so v apnencih radiolariji. Na listu Ljubljana razlikuje Premru (1983) evgeosinklinali in miogeosinklinalni razvoj ladinija. Za evgeosinklinalni razvoj so značilne asociacije pelagičnih sedimentov s piroklastiti ter bazičnimi in kislimi vulkaniti, miogeosinklinalni razvoj pa ponazarjajo pisani pelagični sedimenti. Demšar & Dozet (2003) sta raziskala in opisala pisano ladinijsko zaporedje kamnin v profilu nad Sredniško grapo in Križno Goro. Ladinijska skladovnica, ki leži diskordantno na anizijskem plastnatem in masivnem dolomitu, konkordantno na njej pa leži cordevolski dolomit z ostanki dazikladacej, začenja z bazalno karbonatno brečo, dolomitom in apnencem, navzgor do meje s cordevolskim dolomitom pa si sledijo peščeni tuf z vložki in lečami apnencev, dolomitna breča in dolomit s prehodi v apnenčev brečokonglomerat in apnenec, glinavec, laporovec, lapornat apnenec z daonelami ter vložki tufa, masivni in plastnati tuf z daonelami ter plastnati apnenci in tuf. Ladinijski stolpec Sredniške grape kaže na dve obdobji tektonskega delovanja: 1) na intenzivne tektonske premike in erozijo, ki je ob koncu anizija zajela anizijski dolomit, ter 2) šibkejše ladinijske epirogenetske premike, blokovsko tektoniko ter erozijo, ki je zajela ladinijske plasti.

Konglomerat selških plasti sestavljajo kosi in prodniki anizijskih in starejših kamnin, ki so v različni meri zaobljeni. Njegovi bazalni deli so iz anizijskega dolomita, višji pa tudi iz skitskih sedimentov. Lahko vsebuje tudi tufsko primes. Konglomerat pogosto prehaja v brečokonglomerat ter v pisan peščenjak in apnenčev peščenjak s tufsko primesjo. Osnova je pretežno karbonatna. Sestavlja jo mikrokristalni kalcit, redko dolomit in/ali sericit.

Bazalni konglomerat Selške doline je primerljiv tudi s pisanim ladinijskim konglomeratom, ki izdanja v Tominčevem grabnu v južnih Karavankah in se vleče prek severnega pobočja Medvedjeka (kota 951 m) v ravni črti proti vzhodu, kjer sestavlja večji del Vrse (kota 1140 m) in Kobuja (kota 1204 m). Pas pisanega konglomerata se od tod nadaljuje še proti Dolžanovi soteski. V tem delu Karavank razlikujemo po litološkem videzu dve vrsti konglomerata: 1) sivi konglomerat, ki je sestavljen pretežno iz sivih apnenčevih prodnikov in 2) pisani konglomerat z zelo pestro litološko sestavo različnih kamnin in barv. Oba konglomerata prehajata v vseh smereh postopno drug v drugega. Sivi konglomerat prevladuje na Kobuju, v jugovzhodnem delu Vrse in na več mestih v Tominčevem grabnu. V njem je največ prodnikov sivih apnencev z roženci. Velikost prodnikov se giblje od nekaj do več decimetrov. Redki so slabo zaobljeni bloki s premerom 0,5 m ali celo večji. Razen prodnikov sivega ladinijskega apnenca z rožencem vsebuje sivi konglomerat tudi prodnike sivega apnenca, temnosivega apnenca, temnosivega oolitnega apnenca in zelo redke prodnike rjavega ali zelenega porfirita, keratofirja in rdečega peščenjaka. Vezivo sivega konglomerata je iz mikrokristalnega kalcita, redkeje je peščeno. Pisani konglomerat prevladuje na zahodnem pobočju Vrse in po-

nekod v Tominčevem grabnu. Vsebuje prodnike od trogkofla do ladinija. Barva prodnikov je zelo različna, zato je ta konglomerat lepo pisan. V pisanem konglomeratu največkrat prevladujejo prodniki trogkofelskega rožnatega in svetlosivega apnenca. Pogostni so tudi prodniki rdečega grödenskega peščenjaka. Med kamninami, ki so v sestavi konglomerata precej pogostne, naj omenimo rjave in zelene porfirite in keratofirje. Močno prevladujejo rjavi prodniki. V pisanem konglomeratu se pojavljajo tudi prodniki skitskih in ladinijskih kamnin. Precej pogostni so prodniki skitskega peščenega rumenkastosivega dolomita, skitskega rumenega in rdečega sljudnatega peščenjaka, skitskega olivnega, zelenkastega in rdečega laporovca in skrilavega glinavca, rdečega in sivega oolitnega apnenca, temnosivega rudonosnega apnenca, ladinijskega ploščastega apnenca z rožencem in redkeje grobozrnatega tufa zelenkaste barve. Niso redki tudi prodniki kremena, ki pripadajo najverjetneje karbonu. Vezivo pisanega konglomerata je skoraj vedno bolj ali manj rdeče obarvano. Tvorijo ga zrna pretežno rdečih grödenskih peščenjakov ter skitskih peščenjakov in skrilavih glinavcev.

Nastanek debelih plasti piroklastičnih in litopiroklastičnih kamnin je povezan z intenzivnim vulkanskim delovanjem. Porfirji, keratofirji in diabazi so nastali z izlivi magme. Konglomerati so rezultat nanosov z vodnimi tokovi in zasipavanjem večjih in manjših depresij v reliefu (kotanje, doline). Proti koncu ladinijske dobe so v mirnem in plitvem šelfnem okolju nastali glinavci in meljevci, ki ponazarjajo postopen prehod v plasti psevdoziljske formacije.

Ladinijske plasti stopniškega območja so nastajale na tektonsko aktivnem, morfološko razgibanem plitvovodnem šelfu z močno vulkansko dejavnostjo in sočasnim kopenskim vplivom. Pri nastajanju kamnin sta sodelovali dve erozijski obdobji. V prvem obdobju je šlo za erozijo in odnašanje anizijske podlage, v drugi, ki je potekala v ladiniju, pa tudi za erozijo starejših kamnin.

Pisani konglomerat je pomemben tudi zato, ker se v njem pojavlja limonitna ruda. Limonit nastopa v obliki impregnacij ali pa v obliki limonitnih gnezd v konglomeratu.

Starost pisanega konglomerata smo dobili na podlagi njegove litološke sestave. Ker konglomerat vsebuje prodnike karbonskih, trogkofelskih, grödenskih, skitskih in ladinijskih kamnin, v njem pa ni prodnikov cordevolskih, dachsteinskih in jurskih kamnin, ki so razgaljene v njegovi bližini, je jasno, da sta se pisani in sivi konglomerat odlagala v ladiniju s tem, da se je erozija začela v južnih Karavankah nekoliko pozneje kot v Selški dolini.

Po tem, da ležijo kotno erozijsko diskordantno na anizijskem dolomitu in konkordantno pod cordevolskim dolomitom, so selške plasti podobne ladinijskim plastem Stopnika (Čar & Skaberne, 1995, 2003). Delovanje tektonskih sil v času idrijske tektonske faze (Buser, 1980b; Čar, 1990) je imelo za posledico nastanek zapletene blokovske strukture. Anizijska podlaga je bila tod razrezana s triasnimi prelomi na številne bloke, ki so bili neenakomerno dvignjeni nad erozijsko bazo in nagnjeni v različne smeri. Na posameznih blokih je ostala različna debelina anizijskih plasti. Na erodirani anizijski podlagi leži bazalni debeloprodnati dolomitni konglomerat z redkimi prodniki apnenca in tufskega peščenjaka. Na konglomeratu leže piroklastiti, rožnati organogeni grebenski apnenec, horizont tufskih peščenjakov z izlivi keratofirja, porfirja in mandljastega diabaza. Stolpec ladinijskih plasti zaključi tu sedimentno zaporedje, kjer se menjavajo litični peščenjak, konglomerat in glinenčevolitični prodnati peščenjak.

Razen v podlagi ladinijskih plasti nastopajo na območju Stopnika konglomerati v obliki večjih in manjših leč tudi v tufskih in glinenčevo litičnih peščenjakih. Na območju med Želinom in Jagrščami (Bavec, 1999) ležijo na anizijskem dolomitu s foraminifero *Meandrospira dinarica* Kochansky-Devidé & Pantić erozijsko in kotno erozijsko diskordantno bazalna breča, konglomerat in ponekod dolomit, ki prehajajo navzgor v dolomitizirani pelitski tuf, menjavanje andezitnega lapilnega tufa, debelozrnatega tufa in pelitskega tufa, ki lateralno in vertikalno prehajajo v karbonatne kamnine z vložki antracita (okremenjen apnenec, okremenjen zgodnjediagenetski dolomit). Konkordantno na naštete ladinijske kamnine nalega cordevolski dolomit.

Glede prehoda ladinijskih plasti v karnijske so selške plasti zelo podobne razvojem ladinijskih in karnijskih plasti na Cerkljanskem (Mlakar, 1980). Na Cerkljanskem ležijo na aničnem dolomitu s foraminifero *M. dinarica* Kochansky-Devidé & Pantić piroklastiti kisle sestave z izlivi keratofirja in porfirja ter lečami apnenca. V zgornjem delu vulkanogene serije so bazični piroklastiti (tufi) z diabazom, spilitom in lečami plastnatega laminiranega apnenca. Na diabaznem tufu leži zaporedje sivkasto zelenega drobnika, črnega glinenega skrilavca z lečami temnosivega grebenskega apnenca (psevdoziljske plasti). Krovnino ladinijskega zaporedja kamin sestavljajo amfiklinske plasti zgornjekarnijske starosti (Flügel & Ramovš, 1970). Ker na območju Šebrelj in Stopnika leže bazični vulkaniti in piroklastiti prav tako na kislih vulkanitih in piroklastitih, krovnina pa je tod cordevolski dolomit z algo *D. annulata* Schafhäutl, je Mlakar (1980) sklepal, da je spodnji del psevdoziljskih plasti časovni ekvivalent cordevolskega dolomita in zato karnijske starosti.

Mi uvrščamo sedimente, ki imajo podobno litološko sestavo kot psevdoziljske plasti, še v ladinij, za amfiklinske plasti pa je dokazano (Flügel & Ramovš, 1970), da so karnijske starosti.

Opisani profili dokazujejo vso pestrost in pisanost ladinijske sedimentacije, kar je posledica delovanja tektonskih sil, razmeroma živahne vulkanske dejavnosti in paleogeografske lege. V večjem delu obravnavanega ozemlja sta bili opaženi dve erozijski fazi. V prvi fazi je prišlo do erozije anizijskega dolomita. Druga erozijska

faza pripada ladiniju. Ponekod je bila precej šibka in je erodirala odložene ladinijske kamnine, drugod pa je bila še močnejša od anizijske, saj je zajela skitske, permske in verjetno karbonske plasti.

Iz opisov profilov in posameznih območij je razvidno, da je meja med anizijskimi in ladinijskimi plastmi ponekod normalna, večinoma pa erozijska oziroma kotno tektonsko erozijsko diskordantna. Ladinijske skladovnice pričenjajo največkrat z bazalno brečo, brečokonglomeratom ali konglomeratom. Pred litifikacijo so drobci, kosi in bloki kamnin doživeli krajši ali daljši transport glede na velikosti razkrojenega kamninskega materiala in energije vodnih tokov, ki so jih prenašali.

Zaradi različne intenzitete in različne dolžine trajanja tektonskega in vulkanskega delovanja sedimentacija na obravnavanih ozemljih ni bila sočasna, tako da v nekaterih litoloških intervalih posamezni deli ladinijske sedimentacije manjkajo, ker je tu sploh ni bilo.

Starost ladinijskih plasti je na obravnavanem ozemlju določena z makrofavno (Berce *et al.*, 1960; Ferjančič, 1972; Grad & Ferjančič, 1976; Jurkovšek, 1984; Buser, 1986; Kolar-Jurkovšek, 1990; Bavec, 1999; Šmuc & Čar, 2002) ter Demšar & Dozet (2003), ali s konodonti (Kolar-Jurkovšek, 1990) in radiolariji (Goričan & Buser, 1990).

SKLEPI

Severno obrobje Selške doline je zgrajeno v glavnem iz nizkometamorfnih skrilavcev ter vulkanskih in sedimentnih kamnin ladinijske starosti.

Zaradi specifične litološke sestave in ustrezne razširjenosti predlagamo, da se v tem članku opisano zaporedje nizkometamorfnih, vulkanskih in sedimentnih kamnin skupaj s konglomeratom v podlagi poimenuje Selške nizkometamorfno-vulkansko-sedimentne plasti.

Selške plasti sestoje potemtakem iz bazalnega konglomerata, nizkotemperaturnih skrilavcev, kamnin keratofirsko-spilitne asociacije, bazičnih predornin in sedimentnih kamnin, med katerimi so še zlasti zanimivi in pomembni plastnati laminirani apnenci.

V litostratigrafskem pogledu so selške plasti razdeljene v štiri člene: 1 – bazalni konglomerat 2 – facija zelenih skrilavcev, 3 – kompleks sericitnih in kloritnih skrilavcev ter 4 – kompleks bazičnih kamnin.

Kontakt selških plasti s talnino je razkrit na več mestih med Špičastim hribom in Potoško grapo. Nizkometamorfno-vulkansko-sedimentna formacija leži kotno tektonsko erozijsko diskordantno na temnosivem, plastnatem in masivnem anizijskem dolomitu ter na temnosivem in lapornatem apnencu. Na samem kontaktu se lokalno pojavlja 10 do 20 m debel horizont konglomerata s prodniki in kosi temnosivega sparitnega apnenca, dolomitiziranega apnenca in dolomita. Vmes so leče vijoličnega skrilavega laporovca in glinavca. Vezivo v konglomeratu je lapornato in peščeno.

Krovnina selške formacije je ohranjena med zgornjim delom grape Selnice in Zabrekvami ter na majhnem področju Šmetinca nad dolino Besnice. Sestoji iz psevdoziljskih plasti, ki jih uvrščamo še v ladinij, konkordantno nad njimi pa leže amfiklinski skladi, ki pripadajo že karniju (Flügel & Ramovš, 1970).

Starost selških plasti je določena s fosili in po stratigrafski legi. Fosilni ostanki so v opisanem zaporedju plasti sicer redki, vendar so bili v apnencu, ki se pojavlja med nizkometamorfnimi skrilavci in vulkanskimi kamninami, najdeni elementi sledečih vrst konodontov: *N. trammeri* (Kozur), *N. transita* (Kozur & Mostler) in *Neogondolella* sp. Konodonte je določila Kolar-Jurkovšek. Konodontni elementi in stratigrafska lega dokazujejo ladinijsko starost te formacije.

V drugi polovici anizijske dobe je prišlo do diferenciacije slovenskega ozemlja na plitvo in globlje okolje sedimentacije. Povzročila jo je srednjetriasna predladinijska (Berce, 1963) oziroma ladinijska (Kossmat, 1936) orogeneza. Erozija anizijskega površja je potekala v dveh fazah. V prvi fazi je zajela le anizijski dolomit. Transport materiala je bil kratek. Nastal je homogen brečokonglomerat. V mlajši fazi, nekje v ladiniju, je erozija ponekod zajela predvsem ladinijske plasti, drugod pa je bila intenzivnejša in je zajela tudi skitske, permske in karbonske plasti. Transport erodiranega materiala je bil tokrat daljši in nastal je heterogen pisan konglomerat. Energija vodnih tokov je bila precejšnja, saj v sestavi konglomerata najdemo tudi večje bloke kamnin.

Diferenciacija slovenskega ozemlja se je nadaljevala še v ladiniju in karniju (Buser, 1989). Nastanek piroklastičnih kamnin povezujemo z intenzivnim vulkanskim delovanjem. Material za velike količine tufa na severnem obrobju Selške doline so dale erupcije spilitno-keratofirske asociacije (Grad & Ferjančič, 1976). Kremenovi porfirji, diabazi in bazalti so nastali z izlivi magme. Spiliti so nastali z močno albitizacijo z vodo močno obogatene bazaltne lave. Zeleni skrilavci pa so nastali pri regionalni metamorfozi vulkanskih kamnin, njihovih tufov in sedimentov.

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SELCA LOW METAMORPHIC-VOLCANIC-SEDIMENTARY BEDS, CENTRAL SLOVENIA

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SUMMARY

On the basis of our systematic field and laboratory research for the Geological Map of SFRJ 1:100,000 and the Geological Map of Slovenia 1:50,000 in the Selca Valley and its borderland, we arrived at the following conclusions. The northern borderland of the Selca Valley is built mainly of low metamorphic schists as well as of volcanic and sedimentary rocks of the Ladinian age. Due to the specific lithological composition and corresponding extension we propose for the low metamorphic, volcanic and sedimentary succession the name Selca Low Metamorphic–Volcanic–Sedimentary Beds.

The Selca Low Metamorphic–Volcanic–Sedimentary Beds consist of basal conglomerate, low metamorphic schists, rocks of keratophyre spilite association, mafic eruptive rocks and sedimentary rocks, with limestones of the greatest interest and importance among them.

The considered rock succession is subdivided in the following four members: 1 – Basal conglomerate, 2 – Greenschists facies, 3 – Complex of sericite and chlorite schists, and 4 – Complex of mafic rocks.

The contact of the Selca Low Metamorphic–Volcanic–Sedimentary Beds with its footwall is exposed in several places between Špičasti hrib and Potoška grapa. The low metamorphic-volcanic-sedimentary succession lies transgressively upon the dark grey, bedded and massive Anisian dolomite, and laterally over a dark grey marly limestone. Locally, on the contact itself, a horizon of conglomerate occurs, composed of pebbles and fragments of a dark grey sparitic limestone, dolomitized limestone and dolomite. Within the conglomerate horizon, a violet marly shale and claystone occur. The groundmass of the conglomerate is marly and sandy.

The hanging wall of the Selca Low Metamorphic-Volcanic-Sedimentary Beds has been preserved between the upper part of the Selnica Ravine and Zabrekve as well as in the small area of Šmetinc above the Besnica Valley. It is composed of rocks belonging to the Pseudozilian Beds.

The age of the Selca Low Metamorphic-Volcanic-Sedimentary Beds is defined with fossils and according to the stratigraphic position. Fossil remains are indeed very scarce in the described rock succession, but in the limestone lying among the low metamorphic schists and the volcanic rocks, elements of the following conodont species have been recognized: Neogondolella trammeri *(Kozur),* Neogondolella transita *(Kozur & Mostler) and* Neogondolella *sp. The conodont elements, the stratigraphic position and the characteristic lithological composition of the considered succession prove the Ladinian age of this stratigraphic sequence.*

In the second half of the Anisian period, a differentiation of Slovenian territory in the shallow and deeper sedimentary environments occurred. The differentiation was caused by the Middle Triassic and the Ladinian orogeny. The differentiation of Slovenian territory continued in the Ladinian and Carnian as well. The material for the enormous amounts of tuffs on the northern borderland of the Selca Valley originated from eruptions of a spilite-keratophyre association.

In the considered stratigraphic sequence, two erosion phases have occurred. During the first phase, the Anisian sediments were eroded, while during the second erosion, the older Ladinian beds were removed. In some other parts of Slovenian territory, however, the second erosion removed the Scythian, Permian and Carboniferous rocks as well.

Key words: stratigraphy, lithostratigraphic dismembering, petrography, Middle Triassic, Western Sava Folds

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DELO NAŠIH ZAVODOV IN DRUŠTEV
ATTIVITÀ DEI NOSTRI ISTITUTI E DELLE NOSTRE SOCIETÀ
ACTIVITIES BY OUR INSTITUTIONS AND ASSOCIATIONS

31. KONFERENCA *PACEM IN MARIBUS* "BUILDING BRIDGES TOWARDS INTEGRATED OCEAN GOVERNANCE: LINKING OCEAN SCIENCE, ENGINEERING, TECHNOLOGY AND POLICY"

Redne konference *Pacem in Maribus* so že od ustanovitve nevladne organizacije Mednarodni oceanski inštitut (IOI – International Ocean Institute) forum, kjer se srečujejo strokovnjaki različnih usmeritev, politiki in predstavniki javnosti. Osnovna cilja konferenc sta ohranjanje in širjenje načela o oceanih kot skupni dediščini človeštva. Temeljno vrednoto skupne dediščine je uveljavila ustanoviteljica IOI Elisabeth Mann Borgese, ki ima veliko zaslug za pripravo in uveljavitev konvencije Združenih narodov o pravu morja. IOI danes kot temeljne kamne te usmeritve opredeljuje ekonomski razvoj, varovanje okolja, mir in etiko ter si prizadeva za ohranjanje morij in oceanov v dobro prihodnjih generacij. V skladu s prizadevanji IOI za pravično in trajnostno gospodarjenje z morji in oceani je bila vodilna tema 31. konference *Pacem in Maribus* "Building Bridges Towards Integrated Ocean Governance: Linking Ocean Science, Engineering, Technology and Policy" sprejeta na zasedanju Upravnega odbora IOI oktobra 2004 na Morski biološki postaji v Piranu. Organizacija konference je bila zaupana operativnemu centru IOI v Avstraliji. Vodilna tema konference odseva naraščajočo potrebo po povezovanju in integraciji različnih znanstvenih vej in tehnologij ter političnih usmeritev za izboljšanje kakovosti življenja, varnosti in trajnostnega izkoriščanja morskih virov. V prizadevanjih za dosego teh ciljev je IOI k pripravi konference v Townsvillu pritegnil tudi organizacijo Inštitut za morski inženiring, znanost in tehnologijo (IMarEST). IMarEST je mednarodno profesionalno združenje morskih inženirjev, znanstvenikov in tehnologov s sedežem v Londonu in ima status nevladne organizacije. Organizacijo konference so poleg IOI in IMarEST finančno podprle tudi avstralske organizacije CRC raziskovalni center (CRC RC), Morski park "Veliki koralni greben", Avstralska agencija za mednarodni razvoj (AAID), Avstralski inštitut za morske znanosti (AIMS), Avstralski biro za meteorologijo (AGBM) ter mesto Townsville. Razen avstralskih institucij so konferenco sponzorirale tudi Evropska unija, Medvladna oceanografska komisija in Svetovna agencija za planetarni monitoring in zmanjšanje tveganja zaradi potresov.

31. konferenca *Pacem in Maribus* je potekala od 31. oktobra do 3. novembra 2005 v subtropskem mestu Townsville, v državi Queensland, ki velja za eno najhitreje razvijajočih se držav Avstralije zlasti zaradi izjemnega razvoja z morjem povezanih dejavnosti. Častni gost konference je bil senator Ian MacDonald, avstralski minister za ribištvo, gozdarstvo in varovanje okolja; poleg njega se je konference udeležilo veliko uglednih gostov države Queensland. Vsebinsko je konferenca zajemala šest zelo aktualnih tematik:

- regionalna varnost: okoljske, ekonomske in socialne povezave,
- obalne in morske dejavnosti: okoljski, socialni in ekonomski vplivi,
- tehnologije, nadzor in uveljavljanje pomorskih dejavnosti,
- globalna ocena morskega okolja in modeli alternativ,
- Arafursko in Timorsko morje,
- morska biotehnologija – izzivi in perspektive,

ter kot posebna sekcija

- tveganja naravnih morskih nesreč.

Izhodiščne dileme in izzive vsake tematike je v plenarnem predavanju predstavil vabljeni govorec, sledila so vzporedna predavanja po posameznih sekcijah. Plenarni predavatelji so tematike predstavili iz različnih vidikov, saj so bili po svojih osnovnih strokah zelo različni: od pravnikov, inženirjev, pomorcev, biologov, do politikov. V okviru prve teme je predavatelj opozoril na nevarnosti, ki grozijo morskemu okolju in ljudem, če ne bo v celoti uveljavljena zakonodaja, ki ščiti morja in oceane. Izpostavil je probleme, s katerimi se srečujejo predvsem razvijajoče se države pri udejanjanju konvencije ZN o pravu morja, in ob tem opozoril na odgovornost razvitih držav. Med naraščajočimi nevarnostmi je omenil tudi piratstvo, ki v nekaterih morskih območjih dosega zastrašujoče razsežnosti. V okviru druge teme je bil predstavljen model gospodarjenja z morskim območjem Velikega koralnega grebena v Avstraliji, kjer so vodila: varovanje biodiverzitete, vzdrževanje visoke kakovosti morja in uveljavitev trajnostnih ribolovnih praks. Kot zelo pomembno pri uresničevanju načel trajnostnega gospodarjenja je bilo izpostavljeno izobraževanje. Uvodničar tretje teme je predstavil izzive in uveljavljanje tehnoloških dosežkov pri izvajanju "najboljše prakse" za pomorske dejavnosti in poudaril pomen nadzora. Nove tehnologije so pri tem v veliko

pomoč in bodo zagotovo vplivale na bodočo politiko in pravne okvire pomorskih aktivnosti. Osredotočil se je na onesnaženja z nafto, dredžanje in zasipavanje, varovanje koralnih grebenov in ribiška ter zaščitena območja. Posebej je izpostavil vlogo novih senzorjev, oddaljenega zaznavanja s sateliti, daljinsko krmiljenih plovil, ki omogočajo nadzor z večje razdalje. Podobne tehnike so uporabne tudi pri nadzoru nevarnosti terorizma, tihotapljenja in ilegalnega priseljevanja. Uvodni predavatelj četrte teme se je naslonil na izsledke globalne študije o vodah (GIWA – Global International Water Assessment) in predstavil razvoj teh dejavnosti v prihodnosti. Predvidoma bodo globalne ocene morskega okolja (GMA) pripravljene vsakih pet let, dejavnosti pa bodo potekale pod vodstvom Agencije ZN za okolje (UNEP) in Medvladne oceanografske komisije (IOC). Opozoril je na pomembno vlogo raziskovalcev pri pripravi ocen in na "zasičenost" z dejavnostmi te vrste v državah, kjer je tovrstnih razpoložljivih in primerno izobraženih kadrov malo. Poudaril je tudi pomen seznanjanja javnosti z izsledki in prenosa pravih sporočil politikom. Polzaprtima morjema med Avstralijo, Indonezijo, Timorjem in Papuo Novo Gvinejo – Arafura in Timorsko morje – je bila zaradi nakopičenih problemov in geografske bližine posvečena posebna sekcija. Ti morji sta bogati z naravnimi viri (nafta, plin, ribe), njihovo trajnostno izkoriščanje pa ovirajo nedorečene razmejitve med državami, ilegalno ribištvo in različne stopnje razvoja obalnih držav. V okviru predavanja o izzivih in perspektivah morske biotehnologije je predavatelj razčlenil bogat spekter dejavnosti od akvakulture do raziskav in izkoriščanja učinkovin iz morskih organizmov. Pri tem razvoju je zelo pomembno upoštevanje okoljskih in etičnih izhodišč ter izogibanje "biopiratstvu". Predavatelj je predstavil več pozitivnih primerov avstralskih "biodokritij". Izjemno pozornost na konferenci pa je vzbudila posebna sekcija o tveganjih naravnih morskih nesreč: poleg cunamijev je sekcija obravnavala tveganja zaradi hudih vremenskih pojavov. Predstavitve in razprava so bile osredotočene na možnosti preprečevanja, na razvoj informacijskih in zgodnjih opozorilnih sistemov, predstavljene pa so bile tudi ekološke in socioekonomske posledice nekaterih naravnih katastrof. Poleg uvodnih predavanj je bilo v vsaki sekciji predstavljenih tudi več krajših prispevkov (okoli 70), ki so prikazali različne primere, povezane z osnovno tematiko. Nekateri prispevki so bili predstavljeni v obliki posterjev. Vsaki sekciji je sledila praviloma zelo živahna razprava. Poleg tega je bil pripravljen razstavni prostor, kjer so se predstavile predvsem različne avstralske in mednarodne organizacije. V okviru sekcije spremljanja in nadzora morskih dejavnosti sem predstavila prispevek o možnostih uporabe umetnih substratov za zmanjšanje onesnaženja iz ribogojnic, poleg tega sem predsedovala eni od sekcij. Na razstavnem prostoru je bil predstavljen tudi operativni center IOI Slovenija, ki deluje v okviru Morske biološke postaje Nacionalnega inštituta za biologijo (MBP NIB), razstavljen pa je bil tudi poster mreže odličnosti na področju raziskav morske biodiverzitete MarBEF (6. okvirni program EU), v kateri je eden od partnerjev MBP NIB.

Na konferenci je sodelovalo kakih 150 udeležencev iz 32 držav in več vladnih in nevladnih organizacij. Najštevilnejši so bili udeleženci iz Avstralije in bližnjih tihomorskih držav, dobro so bile zastopane tudi evropske države ter Severna in Južna Amerika. Kot pomembno sporočilo smo na konferenci pripravili deklaracijo in jo poslali generalnemu sekretarju Združenih narodov Kofiju Ananu.

Alenka Malej

10. MEDNARODNI SIMPOZIJ O INTERAKCIJAH MED SEDIMENTOM IN VODO

V zadnjih desetletjih se čedalje bolj zavedamo pomena sedimentov v vodnih okoljih, kar se navsezadnje kaže v intenzivnih raziskavah bioloških, kemijskih, geoloških in fizikalnih procesov. Z namenom, da uporabimo pridobljena znanja v varstvu okolja, je nujno potrebno, da razvijamo multidisciplinarni pristop, ki povezuje temeljne in uporabne raziskovalce, modeliste, eksperimentalce, znanstvenike, ekonomiste in upravljalce. Mednarodno združenje za raziskave sedimentov in vode (IASWS) je tradicionalno usmerjeno v študij različnih vidikov vodnih okolij in sedimentov in je do danes združilo vrsto raziskovalcev z različnih znanstvenih disciplin. Dosedanji simpoziji o interakcijah med sedimentom in vodo so potekali na Nizozemskem (1976), Kanadi (1981, 2002), Švici (1984), Avstraliji (1987), Švedskem (1990), ZDA (1993), Italiji (1996) in Kitajskem. 10. simpozij je potekal med 28. avgustom in 2. septembrom 2005 na Bledu v organizaciji Instituta Jožef Stefan in Nacionalnega inštituta za biologijo. Obe inštituciji se že vrsto let ukvarjata z raziskavami procesov v vodah in sedimentih doma in v tujini. Blejsko jezero je zaradi intenzivnih bioloških, biogeokemijskih in hidroloških raziskav, ki so bile tam opravljene v zadnjih 20 letih, ustrezno mesto za simpozij te vrste. Na njem je približno 180 udeležencev iz 35 držav predstavilo prek 250 prispevkov v obliki referatov in posterjev s sledečimi tematikami:

- izvor in vpliv sedimentov na sladkovodne in morske ekosisteme,
- modeliranje procesov v sedimentih,
- hranila in onesnaževalci v sedimentih,

- asanacija onesnaženih sedimentov,
- vpliv bioloških procesov na izmenjavo sediment-voda.

Prispevki s simpozija bodo prispevali k boljšemu razumevanju procesov, ki potekajo med sedimentom in vodo, transporta hranil in onesnaževalcev ter s tem človekovih vplivov. Simpozij je združil nova znanstvena spoznanja za boljše upravljanje z vodnimi viri in ustrezno zakonodajo. Poleg tega je omogočil primerjavo rezultatov, pridobljenih z različnimi metodologijami, in bo prispeval k usklajevanju metodologij za reševanje problemov v lokalnem, regionalnem in globalnem obsegu. Cilj simpozija je bil tudi širiti spoznanja in izkušnje na področju raziskav sedimentov in interakcij med sedimentom in vodo ter onesnaženja, ki je posledica človekove dejavnosti. Simpozij je tudi omogočil sodelovanje mlajših raziskovalcev pa tudi raziskovalcev iz držav v razvoju, kar bo nedvomno omogočilo prenos znanja, izkušenj in ustreznih rešitev v manj razvite države. Organizacijo simpozija je poleg Ministrstva za visoko šolstvo, znanost in tehnologijo podprlo še 16 inštitucij in podjetij. Daljši povzetki in izvlečki prispevkov so zbrani v zgoščenki in v 1. številki letnika 52 revije RMZ – Materials and Geoenvironment, izbrani prispevki pa bodo objavljeni v posebni številki revije Water, Air and Soil Pollution.

Slovenski znanstveni prispevek k simpoziju je bil precejšen in pomeni promocijo naše znanosti s področja varstva okolja na mednarodni ravni. **B. Ogorelec** z Geološkega zavoda Slovenije je s sodelavci v plenarnem predavanju predstavil recentni sediment Blejskega jezera iz sedimentološkega in geokemijskega vidika. Iz podatkov sta razvidna naraščajoča evtrofikacija in onesnaževanje jezera predvsem v zadnjih 50 letih. **Š. Remec Rekar** z Limnološke postaje je predstavila rezultate 20-letne asanacije Blejskega jezera z vnosom reke Radovne in natege, ki so predvsem vidni v zmanjšanju koncentracij hranil in fitoplanktonske biomase. **J. Faganeli** z Morske biološke postaje Nacionalnega inštituta za biologijo in sodelavci so prikazali geokemijske lastnosti podvodnega izvira pri Izoli. Te nakazujejo, da je izvirska voda, ki je podobna kraški podtalnici, delno mešana (približno 15%) z morsko vodo. Vnos kovin in hranil z izvirom v Tržaški zaliv je manjšega pomena glede na druge vnose (pritoki, padavine). **L. Globevnik** z Univerze v Ljubljani in **M. Kaligarič** z Univerze v Mariboru sta predstavila hidrološke spremembe reke Mure in poslabšanje razmer v habitatu zaradi postavitve jezov, ki se kaže predvsem v znižanju jezerskega dna, podtalnice in povečane erozije. **E. Heath** z Instituta Jožef Stefan in sodelavci so prikazali porazdelitev poliaromatskih ogljikovodikov (PAH) v jedru dveh vrtin, ki sta predrli celoten holocenski sediment Tržaškega zaliva. Podatki kažejo, da so se v zadnjih 50 letih povišale vsebnosti PAH v plasteh sedimenta. Iz razmerij posameznih PAH sklepajo, da je izgorevanje in vnos nastalih produktov s pritoki in atmosfersko depozicijo najpomembnejši vnos v zaliv. **M. Horvat** z Inštituta Jožef Stefan je predstavila pomen referenčnih materialov v analizni kemiji okolja na primeru živega srebra. **T. Kanduč** z Inštituta Jožef Stefan in sodelavci so predstavili nastanek lignita v velenjskem bazenu z uporabo stabilnih izotopov ogljika. Ugotovili so obstoj metana in CO_2 mikrobnega izvora, endogenih CO in CO_2 ter CO_2 iz karbonatov, litotipi lignita pa se razlikujejo glede na biogeokemijske procese zgodnjega nastajanja. **D. Kocman** in sodelavci z Instituta Jožef Stefan so prikazali prednosti razklopa s kislinami, ki vsebujejo fluorovodikovo kislino, v določanju celotnega živega srebra (Hg) v trdnih okoljskih vzorcih. **J. Kotnik** z Instituta Jožef Stefan in sodelavci so prikazali porazdelitev izbranih kovin v sedimentu reke Save. Z normalizacijo vsebnosti glede na aluminij so ugotovili povišane vsebnosti vseh izmerjenih kovin v bližini Železarne Jesenice (Acroni) in večjih urbanih naselij. **N. Kovač** z Morske biološke postaje Nacionalnega inštituta za biologijo in sodelavci so predstavili uporabo infrardeče spektroskopije (FTIR) za določanje sestave in izvora organske in anorganske snovi v sedimentih Tržaškega zaliva. **S. Lojen** z Instituta Jožef Stefan in sodelavci so prikazali biogeokemijsko kroženje žvepla v sedimentu Zaliva Authie (Francija) z uporabo vsebnosti in porazdelitve stabilnih izotopov žvepla. Ugotovili so, da je organske vezano žveplo poleg biološkega izvora tudi produkt diagenetske sulfurizacije huminskih snovi z delno reduciranim ali recikliranim raztopljenim žveplom. **N. Ogrinc** z Instituta Jožef Stefan in **J. Faganeli** z Morske biološke postaje Nacionalnega inštituta za biologijo sta s prikazom rezultatov inkubacijskega poskusa dokazala, da je razgradnja organske snovi najpomembnejši izvor fosforja v sedimentih Tržaškega zaliva in da poteka hitreje v anoksičnih okoljih. Masna bilanca pokaže, da približno polovica fosforja ostaja trajno vezana v sedimentu. **A. Šomen Joksič** z Zavoda za zdravstveno varstvo Koper in **M. Horvat** z Instituta Jožef Stefan sta predstavila sekvenčno ekstrakcijo kovin iz morskega sedimenta in njihovo potencialno mobilnost. **F. Ulaga** z Agencije Republike Slovenije za okolje je prikazala vsebnosti in transport suspendiranih delcev v nekaterih slovenskih rekah. **P. Vreča** z Instituta Jožef Stefan in **G. Muri** z Nacionalnega inštituta za biologijo sta predstavila uporabo stabilnih izotopov v študiju biogeokemijskega kroženja ogljika in dušika v evtrofnem visokogorskem Jezeru na Planini. **M. Cotman** s Kemijskega inštituta in **J. Zagorc Končan** z Univerze v Ljubljani sta nas seznanila z nekaterimi novimi ekotoksikološkimi pristopi v določanju točkastih izvorov onesnaženja, ki vsebujejo kemijske analize, toksikološke študije in biološko razgradljivost v rečni vodi in sedimentu, na primeru odpadnih voda usnjarske industrije in komunalnih odplak. **M. Markič** z Geološkega zavoda Slovenije in sodelavci so prikazali povezanost med lastnostmi slovenskih premogov in prvotnimi interakcijami med šoto,

vodo in sedimentom v okolju v času nastajanja. **N. Mori** in **A. Brancelj** z Nacionalnega inštituta za biologijo sta prikazala vpliv različnih perturbiranih okolij na hiporeične združbe v štirih slovenskih rekah. **S. Murko** in sodelavci z Instituta Jožef Stefan so prikazali uspešno uporabo mikrovalovnega razklopa v analizi kadmija in svinca v vodnih sedimentih. **A. Osterc** in **V. Štibilj** z Instituta Jožef Stefan sta nas seznanila z analizami vsebnosti joda-129 v sedimentih Jadranskega morja. **J. Ščančar** z Instituta Jožef Stefan in sodelavci so predstavili porazdelitev organokositrovih spojin in nekaterih kovin v sedimentih reke Ljubljanice in Tržaškega zaliva. Vsebnost organokovinskih spojin v Ljubljanici in Tržaškem zalivu je razen v bližini čolnarn oziroma marin in izolske ladjedelnice razmeroma nizka. **E. Heath** z Instituta Jožef Stefan in sodelavci so predavali o učinkovitosti biološke razgradnje ostankov nesteroidnih farmacevtskih preparatov proti vnetjem v jezerski in rečni vodi ter sedimentih. Rezultati kažejo na obstoj ostankov v okolju kljub predhodnemu čiščenju odpadnih vod.

Jadran Faganeli in Nives Ogrinc

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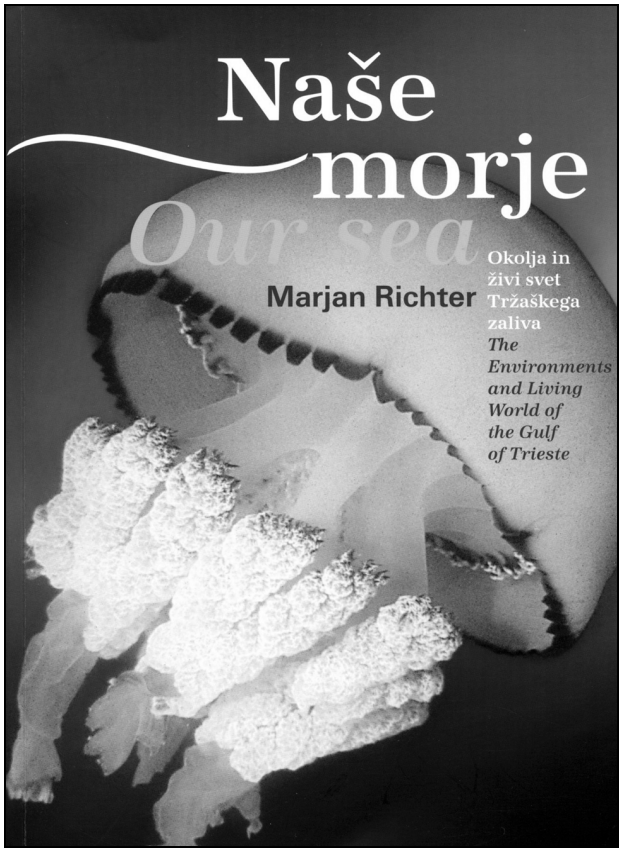
Marjan Richter: NAŠE MORJE – OKOLJA IN ŽIVI SVET TRŽAŠKEGA ZALIVA

Ob 14. rednem zasedanju pogodbenic o varstvu morskega okolja in obalnih območij Sredozemlja in njegovih protokolih v Portorožu v začetku novembra 2005 je izšla lična, s fotografijami bogato opremljena knjiga našega priznanega podvodnega fotografa Marjana Richterja z naslovom "Naše morje – Okolja in živi svet Tržaškega zaliva".

Publikacija, ki jo je izdala založba Sijart, je nekakšen fotografski pregled življenjskih okolij v slovenskem morju in njegovih organizmov ter predstavitev sinteze petdeset let dolgega spoznavanja in raziskovanja biotske raznovrstnosti v vseh njenih dimenzijah; od najmanjših cianobakterij in drobnih fitoplanktonskih alg pa vse do morskega psa orjaka. Spremljajoče besedilo je v slovenskem in angleškem jeziku. V glavnem je jedrnato in nas pouči o vsebini posameznih fotografskih sklopov. Vsako poglavje oz. fotografski sklop je označen s posebno barvo. Med drugim lahko izvemo marsikaj o živalskih in rastlinskih vrstah, ki so podnajemniki v naseljih alg, mojstri prikrivanja, živi filtri, pa o pojavih, kot je cvetoče morje, in še kaj. Marjan Richter je v knjigi predstavil tudi nekatere dogodke, npr. podvodni posnetek morskega psa orjaka, in nekatere vrste živali, kot je morska lilija, ki jih danes ni več v našem morju. Kdor avtorja pozna osebno, ve, da se vsakega problema loti zelo resno. Ko se je pričel leta 1999 zanimati za babice, ni odnehal, dokler ni poslikal vseh na piranski punti živečih vrst. Lahko bi rekli, da je fotografija postala Marjanovo orodje za raziskovanje biotske raznovrstnosti slovenskega morja. Nekoč mi je pravil, da ni slovensko morje prav nič manj zanimivo od živopisanih organizmov koralnih grebenov v tropskem morju. Kaj takega lahko reče samo nekdo, ki tako dobro kot on pozna biotsko raznovrstnost tropskih morij. Avtor je knjigo posvetil Ivanu in Dušanu Kuščerju, slovenskima pionirjema potapljanja, ki sta Marjana Richterja naučila potapljanja in opazovanja narave, s tem pa tudi za vedno zaznamovala njegovo življenje.

Malo manj kot 400 strani debelo knjigo krasi 780 fotografij, ki predstavljajo približno 600 vrst različnih morskih organizmov. Vse fotografije so, kot je bilo od mojstra Richterjevega kova pričakovati, skrbno izbrane in tehnično popolne. Morda so v Sloveniji fotografi, ki so skoraj tako vešči kot Marjan Richter v fotografiranju rib in bentoških organizmov, zagotovo pa ni fotografov, ki bi bili takšni mojstri mikroskopske fotografije. Naj za primer navedem tintinide, planktonske migetalkarje z lično loriko, to je hišico iz proteinov ali pa nakopičenih zrnc organskega drobirja. O tintinidih tudi razgledani zoologi vedo bolj malo. V knjigi lahko najdemo kar sedem vrst teh planktonskih arhitektov. Nič manj zanimive niso slike kremenastih alg, oklepnih bičkarjev, planktonskih ličink številnih skupin nevretenčarjev in drugih.



Publikacija Naše morje – Okolja in živi svet Tržaškega zaliva je torej posrečen prikaz biodiverzitete v slovenskem morju, kot ga je v petdesetletnemu obdobju doživel, spoznal in fotografiral Marjan Richter. Bralca bo gotovo navdušilo izjemno bogastvo morskega življa in njegova barvitost, ki ju premore naše morje. Kakovostni izbor bogatega fotografskega gradiva in zanimive razlage avtorja, ki se praviloma raje opira na svoje z izkušnjami pridobljeno znanje, odtehta nekatere napačno določene vrste, ponekod preveč poenostavljene in zato špekulativne razlage, neustrezna imena in tiskarske škrate. Gotovo bi bila tudi smiselna uporaba poenotenega in po možnosti sodobnejšega latinskega imenoslovja. Še najbolj moteča je pomanjkljiva navedba virov v poglavju o literaturi.

Vse omenjeno pa, kot že rečeno, ne spremeni

dejstva, da smo Slovenci dobili kakovosten pregled biotske raznovrstnosti našega morja skozi oči fotografa, ki je to izdelal na podlagi bogatih izkušenj raziskovanja slovenskega morja. Bralce bo ta album slik biodiverzitete, ki ga je avtor dopolnjeval dolgih petdeset let, gotovo navdušil in prepričal o bogati zakladnici morskega življa. Publikacija je primerna za vse, ki jih zanima biodiverziteta najsevernejšega dela Jadrana.

Lovrenc Lipej